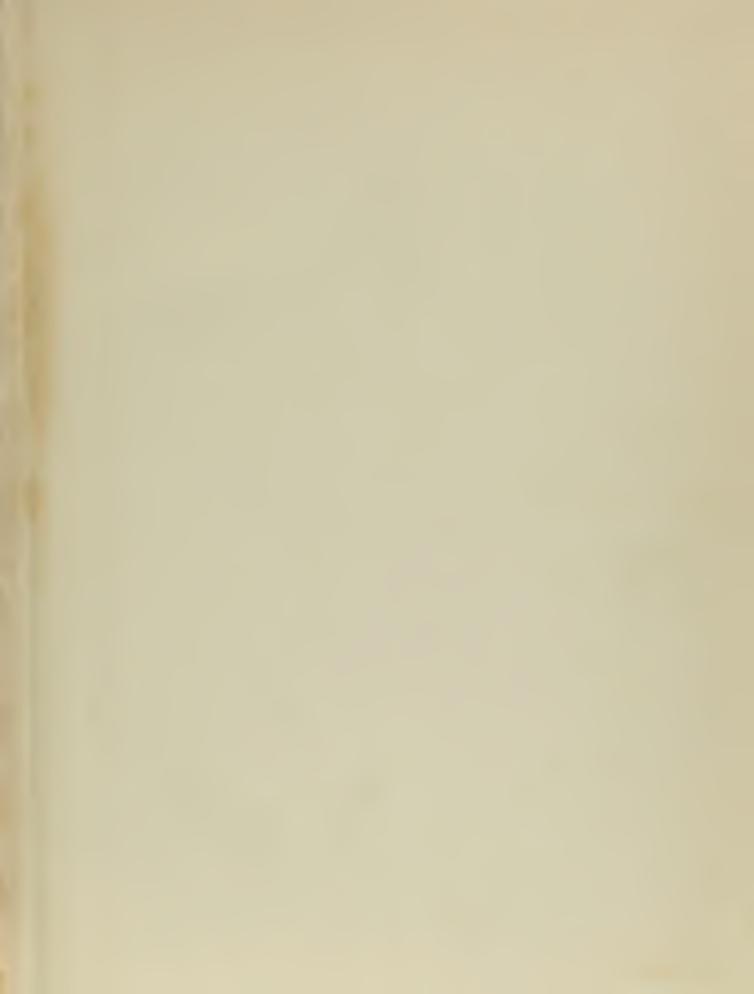
AN INVESTIGATION OF THE RADIONUCLIDES OF ARSENIC PRODUCED BY CYCLOTRON BOMBARDMENT OF GERMANIUM WITH 15 MEV DEUTERONS

HARRY J. WATTERS AND JOHN F. FAGAN, JR. Labrary
U. S. Naval Postgraduate School
Monterey, California









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Title: "An Investigation of the Radionuclides of Arsenic
Produced by Cyclotron Bombardment of Germanium
with 15 Mev Deuterons"

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Authors: Harry J. Watters, Lieutenant Commander, U.S. Navy
B. S., Purdue University (1849)

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John F. Fagan, Jr., Lieutenant, U. S. Navy B. S., U. S. Naval Academy (1945)

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Submitted to the Department of Physics on May 25, 1953 in partial fulfillment of the requirements for the degree of Master of Science.

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The arsenic produced by a deuteron bombardment of germanium has been studied to determine the nuclides present in the mixture. Identification of isotopes was made by comparing measured values of half life and maximum \$\beta\$ energy with the accepted values. Yield values were determined for each isotope present by 4r solid angle counter measurements.

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Counting rates were measured for a period of 53 days with 4v and coincidence counters, obtaining half lives which indicated that the nuclidic mixture was made up of As⁷¹, As⁷², As⁷³, As⁷⁴, and As⁷⁷. These indications were confirmed by maximum β energy values obtained by absorption measurements and from γ energies found using a γ-ray scintillation spectrometer. Measurements indicated that the 40 hour half life reported for As⁷⁷ is in error by a significant amount, and that no As⁷⁶ was obtained by this bombardment.

The 4# solid angle counter constructed was shown to have an efficiency of very nearly 100 percent for particles which escape the source. This counter has proven to be a very practical laboratory instrument and detailed instructions for its use are included as an appendix.

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The following is a tabular summary of the results of the investigation:

sotope	Method of decay	Energy (Mey)	T _{1/2}	Thick target yield* (uc/usmp-hr)
As 71	8+	0.68	48.2 ± 1.2 hrs.	7.6
As72	β ⁺	3.25	25.8 ± 0.2 hrs.	64.9
As 73	g- 0.	11>E _{max} >0.02	68.9 ± 9.2 days	1.1
1874	ALPINES ILA	0.99, 1.49	17.8 ± 0.13 day	8 5.2
A. 76		Not present in	the mixture	
A. 77	ar the Day	<0.7	>70 hours 5	< yield < 15**

^{*} The thick target yield values specified apply if the deuteron beam current was exactly 36 mamps and if the arsenic separation efficiency was 100 percent. Yield values quoted are based on \$ counting only and do not include orbital electron capture.

Thesis Supervisor: Robley D. Evans

Title: Professor of Physics

^{**} Based on ratios of total \$ to \$ counting rates.

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ACCHONLEDOMENTS

The authors wish to express sincere thanks to their thesis advisor, Professor Robley D. Evans, for his interest and advice during the course of this work. Grateful acknowledgment is also made to Doctor Gordon L. Brownell, who suggested the problem, for his constant guidance and for the opportunity to utilize the facilities of the Massachusetts General Mospital Research Laboratory.

Thanks are due to all members of the group in the Radioactivity Center for their interest and suggestions. The opertunity for graduate study provided by the Radioactivity Center and its sponsors is greatly appreciated.

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I. INTRODUCTION

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A. Importance of the Investigation

large amount of trace metal compared with that taken up by normal brain tissue makes it possible to detect and to actually determine the location of tumors in the human brain. Under the supervision of Dr. Gordon L. Brownell, a group at the Research Laboratory of the Massachusetts General Mospital has developed a suitable tracer technique for the diagnosis and preoperative location of brain tumors, using positron emitting isotopes. After intravenous injection of the tracer material, the patient's head is mechanically scanned in two dimensions by two scintillation counters connected in coincidence. Third dimensional location is obtained from the unbalanced single channel counting rates of the separate counters.

Since January 1953 a large number of patients have been examined using this technique. The results are

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outstanding. From many cases clinically diagnosed os perderline, the presence or absence of neoplastic brain tissue has been determined by this method. In all cases where surgary was performed, tumor location obtained by this technique has been confirmed. As yet no known incorrect diagnoses have been made. In addition to providing more quantitative information than is available from clinical diagnosis, this method provides the left-to-right localization which is difficult and often impossible to obtain clinically.

metal because of several considerations. Arsenic is readily available from a deuteron bombardment of germanium. The half lives of arsenic isotopes fall within an acceptable range for tracer utilization.

Host of the y-rays emitted from arsenic isotopes are soft, thus decreasing harmful biological effects due to radiation. A very important advantage is that a large percentage of arsenic activity consists of positron emission. Precision measurements with very high resolution may be made on the resulting annihilation radiation.

The tracer arsenic is not injected until several days after bombardment. During this period any short-

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value compared with that of the 17.5 day isotope (11,13) and does not affect the scanning measurements which require a period of approximately two hours. If the half lives and the relative activity percentages of the short-lived isotopes were accurately known, this waiting period could be decreased or even eliminated with a resultant increase in useful activity obtained from a given bombardment.

determine insefar as possible the methods of decay and associated decay energies, half lives, absolute activities, and isotopic yields of the arsenic obtained by the deuteron bombardment of germanium. In addition to decreasing the delay between bombardment and injection, this information may permit the use of short-lived isotopes as tracers. In effect this also decreases the bombardment time required to obtain a given amount of tracer material. It may be desirable to examine a single patient several times over a period of a few weeks. Accurate knowledge of the short-lived activity present may permit frequent injections of a lesser amount of tracer solution while avoiding harmful effects from the chemical toxicity of carrier arsenic present.

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B. Results of Previous Investigations

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Prior to Eagane's investigations in 1938⁽¹⁾ very little was known about the radionuclides of arsenic. The principal results of his work on the arsenic produced by a deuteron bombardment of germanium, as modified by others, are tabulated below and include all data reported through 1941.

Isotope	Type radiation	Energy (Nav)	Balf life	Reference
As 71	B+	5,04	60 hour	2, 4
As 73	0+	0.6	68 min	2, 4
As 74	8*	0.9	16 day	1, 4
As 76	B	1.1 }		
		1.7		
		E.7	96.8 hour	3, 5, 6
	Υ	1.5	111	
		2.2		
	870-50	3.2 5	15/1 (6)	31, 38
As 77	4.		55-90 day	1, 2, 4
2279	4" X" 4 94			
As 78	Υ ,	0.27	66 min	7

Very little new information was published for several years but commencing in 1948 results were published which

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conflicted with such of the previous data. The following is a tabulation of the most reliable data now available on the radioisotopes of arsenic without regard to their method of activation:

Isotope As70	Type radiation	Energy (May)	Half life	Reference
As n	8 ⁺ (33 %) E (67%)	0.6	sould the no	10, 11, 12
A 5 72	C LLTINA LINE & COURS	0.97 0.67 1.84 2.5 3.34 0.70	26 hour	9, 11, 19
A. 73	K no β [†]	0.835	76-100 day	11
As ⁷⁴		0.69, 1.36	17.5 day	11, 13
As 76 3	Y +/5 4 0.07	0.593 %		
As 77		0.55, 1.21		14, 18
	no y		40 hour	15, 16, 20

additions our area areather years not be reasonable as at all of the later than the second of the later and the second of the second of the later and the second of the se

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		V-1 (979.1)	-	. This
parter org	12001 (0)		7.00	

II. NUCLEAR PROPERTIES TO BE MEASURED

an investigation which could determine actual decay schemes of the active material. With a desire to extract as much information as possible in the time available, attempts were made to determine the following for each isotope of arsenic obtained from the bombardment:

- 1. Absolute B activity.
- 2. Half life. The same to be the terminal than
- 3. Hazimum β energies.

In addition it was desirable to obtain information regarding the y-energies of the mixture of isotopes and the variation of the spectrum with time.

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III. EXPLRIME TAL PROCEDURE

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A. Preparation of Radioactive Arsenic

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A chip of pure germanium metal 1/3% inch thick
with dimensions 3/8 inch by 1 inch was used as a
target in the M.I.T. cyclotron. This chip was
bombarded with 15 Mev deuterons for a period of 20
minutes with an average beam current of 36 memps.

to GeCl₄ in an evacuated system using gaseous Cl₂.

To this was added HCl, H₂O₂, and arsenic carrier after which the bulk of the GeCl₄ was distilled out. The arsenic remaining in the solution as \(\lambda \structure{5} \) was precipitated as a metal by the addition of ammonium hypophosphite. A detailed description of this separation procedure is contained in reference 21.

B. Schedule of Observations

COMPANY OF TAXABLE OF

gration rate of the active material by use of the 4s and coincidence counters. In an attempt to ascertain

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whether or not the arsenic cont ined any positronemitting isotopes having half lives of the order of 1
hour or less (2,3,17,23,24), coincidence counter measurements were made as follows: each minute during the
third hour after book rement, every 5 minutes during
the fourth hour, every 10 minutes during the fifth hour,
and every 15 minutes during the sixth hour. Thereafter
the maximum interval between measurements was adjusted
to approximately 1/10th the value of the half life
indicated by a continuous plot of counting rate observations.

Pue to the time required for preparation of 40 counter sources and the time involved in making absorption measurements with the end window 8 counter, observations with these instruments were made hourly from the 6th through the 17th hour after bombardment, and thereafter in accordance with the schedule cutlined above.

Using the sodium iodide scintillation spectrometer described in Appendix II an initial scan of the energy spectrum up to 3 MeV was made within three hours after bombardment in order to determine the maximum energy y-rays emitted from the arsenic. With no detectable y-energies present greater than 1 MeV, an operating range

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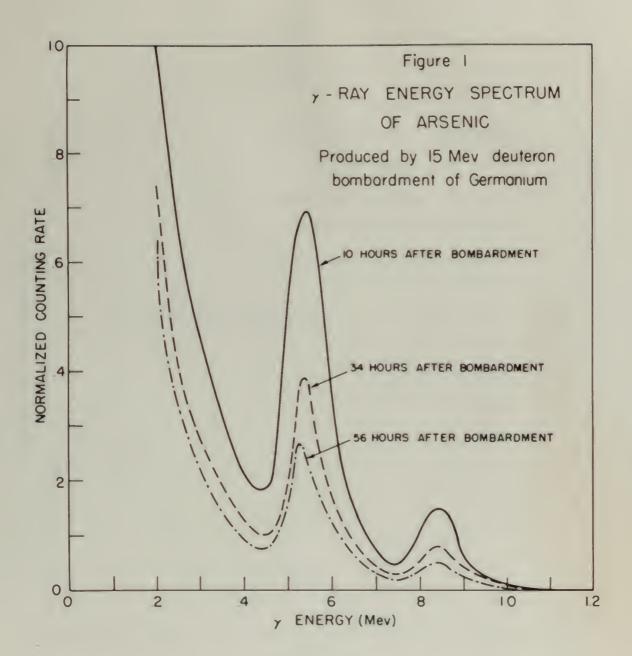
was enosen which included all y-energies up to approximately 1.3 Nev. This energy range was scanned continually for the first 72 hours after bombarament (Fig. 1). The high energy range was scanned at intervals during this period with negative result. An additional energy spectrum was obtained 52 days after bombarament (Fig. 2) and as before, no high energy y-rays were detectable.

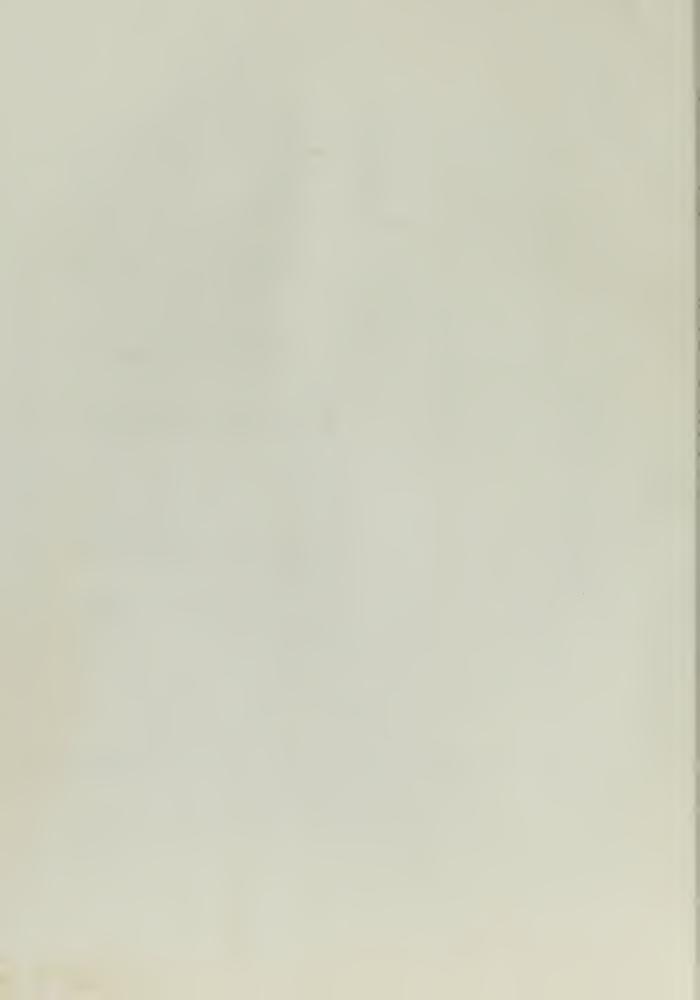
Using the end window counter, counting rates were measured for absorber thicknesses of from zero to 2526 mg/cm. Observations were made in accordance with the time schedule previously given.

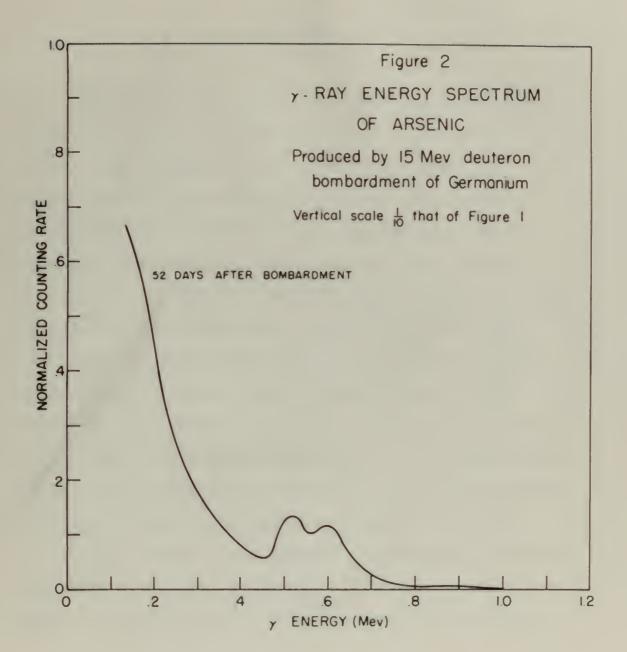
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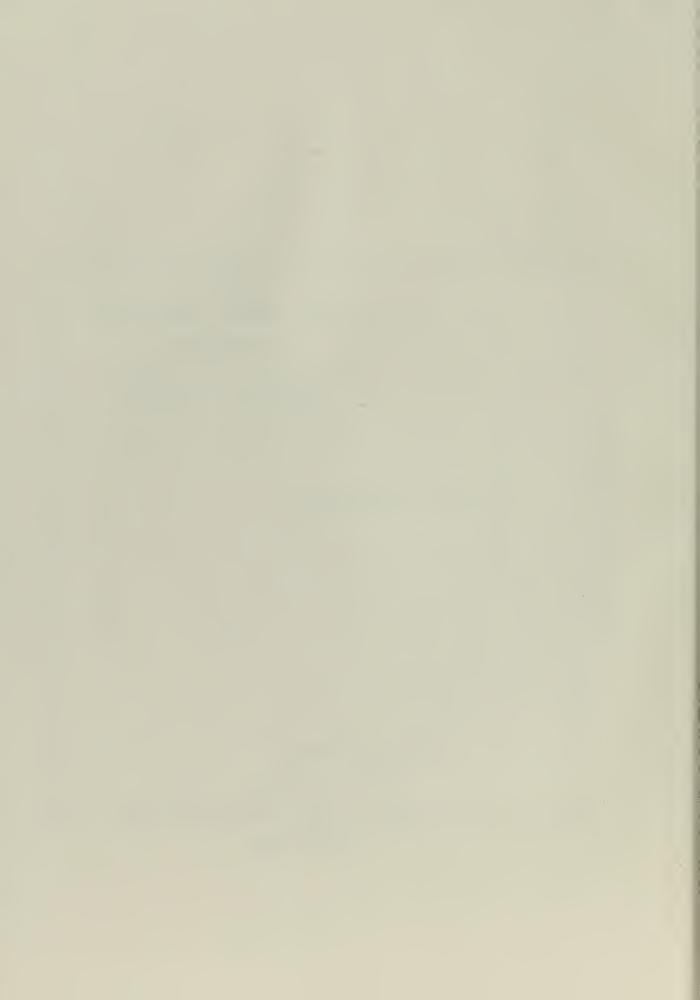
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IV. MITIOUS USED IN INTERPRITATION OF DATA

A. H lf Life

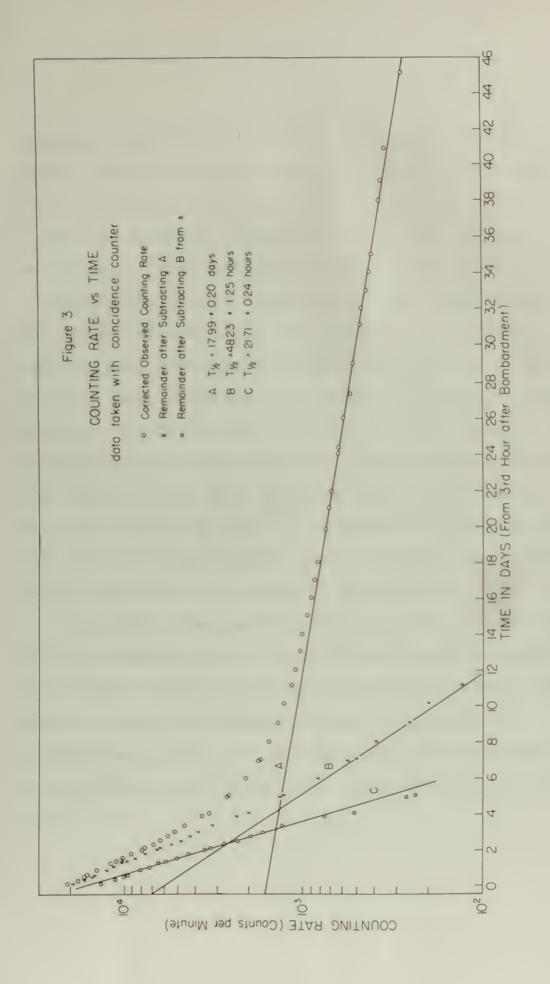
Observed counting rate, corrected for instrumental error, was plotted on a mile, aper as a function of time. Approximately 20 days after book rement the curve obtained from coincidence measurements assumed a constant slope indicating the presence of a single isotope. Application of the method of least squares to data in the region of constant slope yielded a determination of half life, zero time activity, and their respective standard deviations. Subtraction of values thus obtained from the curve of total counting rate resulted in a residual curve also possessing a constant final slope. Successive application of this method permitted the resolution of 3 straight line components from the data obtained by coincidence counting (Fig. 3).

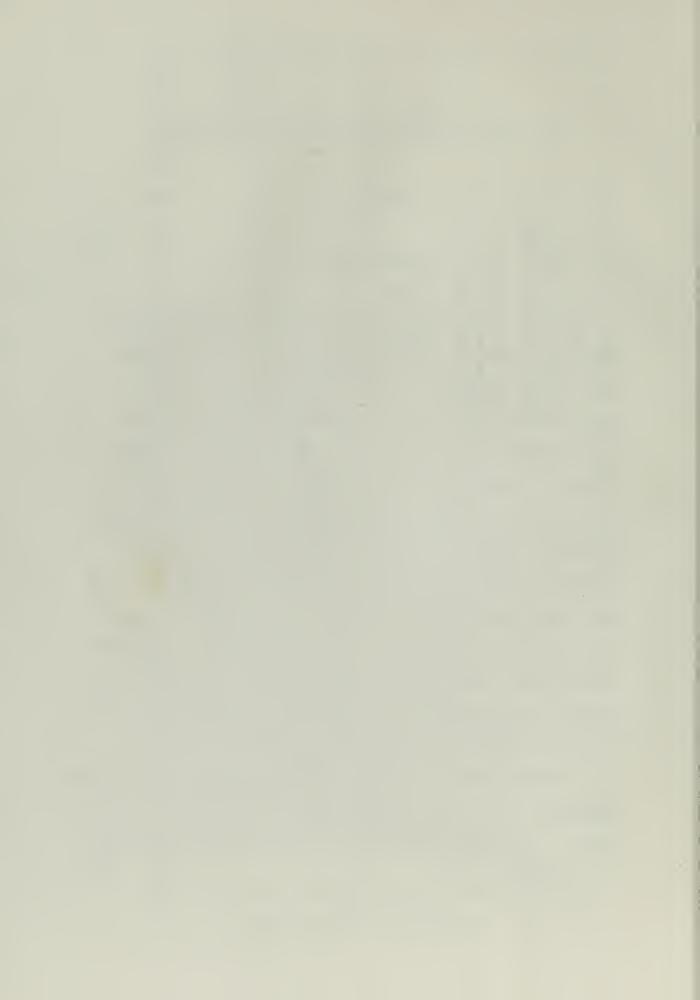
The 4x counter data included a relatively long-lived component which was not apparent in coincidence measurements. Assuming this to be As 73 reported as a 0.05 MeV

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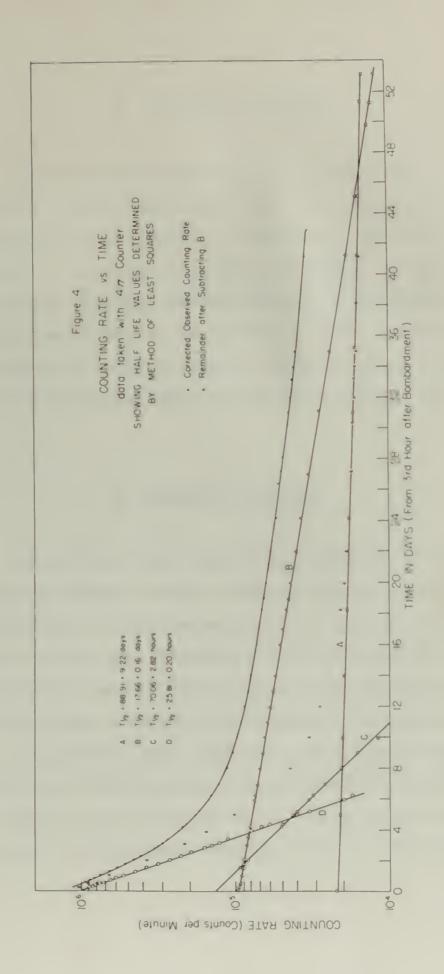


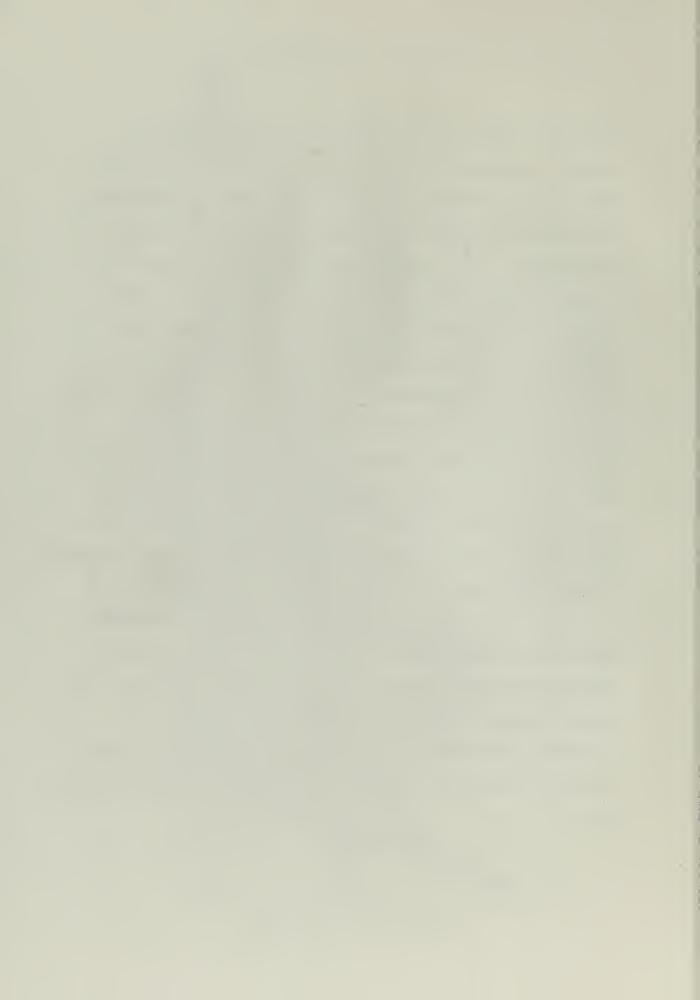


counter source was covered with 13.7 z=/cm² of aluminum foil (a thickness equivalent to ~ 3 times the range of a 0.05 Mev electron) commencing on the 41st day after both remain. Let obtain with this source plotted as a straight line with a half life of 17.56 days. After subtraction of this 17.66 day activity from the total counting rate curve the compatant slope extraity of the residual curve indicated a half life of ~85 days. This procedure permitted early evaluation of data without waitin, for the predominance of the 59 day component and the results are in good agreement with the As 73 method of decay reported by Mei. (19) Successive application of the method of least squares to the 4x counter data resulted in the resolution of 4 straight line components. (Fig. 4)

Half life determinations were also made from semilog plots of counting rate vs time obtained using absorbers of specific thickness with the end window s counter. The method of curve subtraction previously outlined was employed and a total of 3 straight line components were resolved having half lives of £6 hours, 59 hours, and 16.7 days.

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B. Absolute & Activity

Since the efficiency of the 4% counter for \$ counting is quite high (Appendix I), these data were used in the determination of absolute activities. The zero time activities obtained in applying the method of least squares to half-life determination were corrected to the time of completion of bombardment. These results can be specified in terms of yield if specific values of deuteron beam current and arsenic separation efficiency are assumed.

C. Haximum & Energies

These values were found from absorption curves obtained by use of the end window β counter (Appendix III). From measure ents of maximum range made at various times the energy of the most energetic β was determined for both the 26 hour and the 17.5 day isotopes. The method is illustrated in Fig. 5 which is applicable to the 26 hour isotope.

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In addition, mass absorption coefficients were determined from semilog plots of counting rate vs absorber thickness taken at various times. Using these values maximum & energies were determined for the 17.5 day and

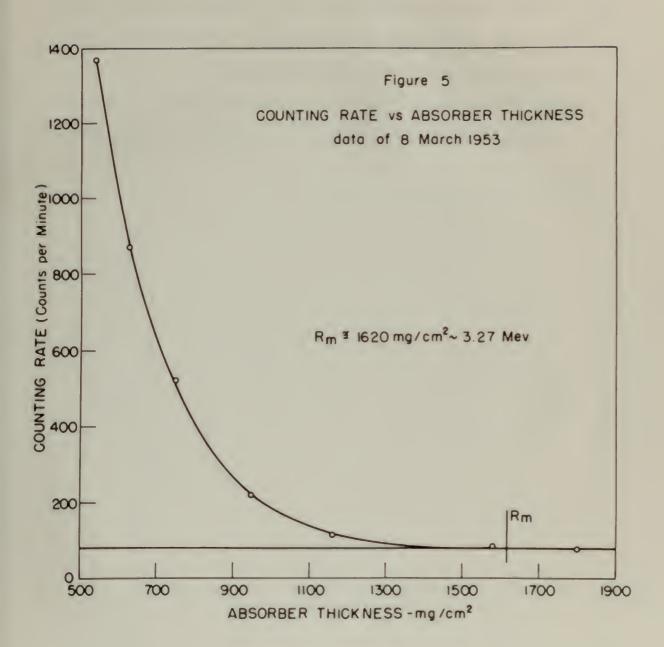
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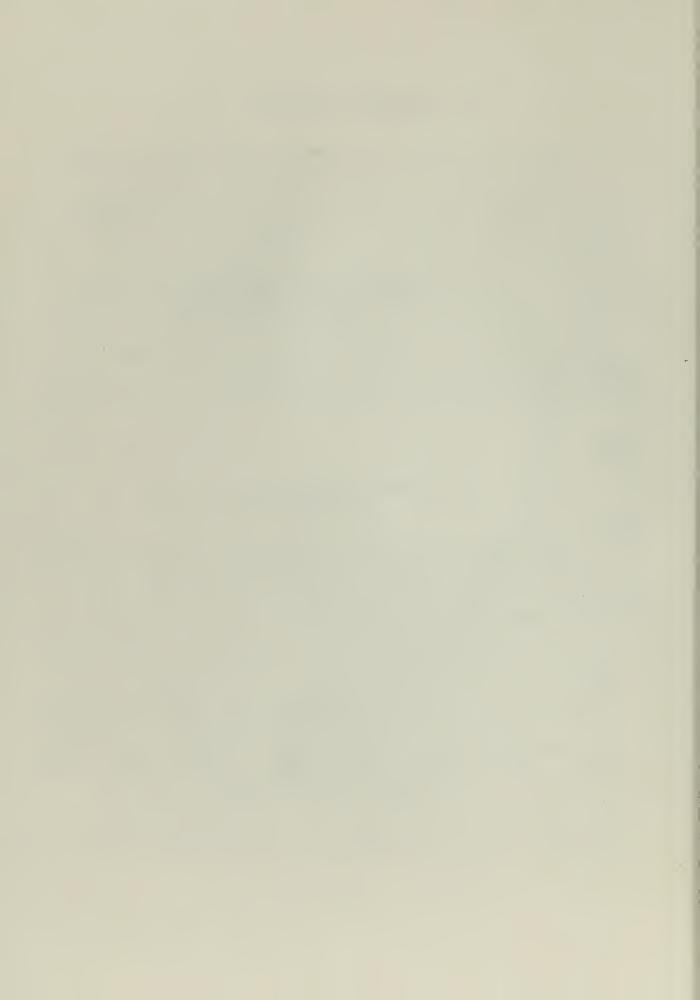
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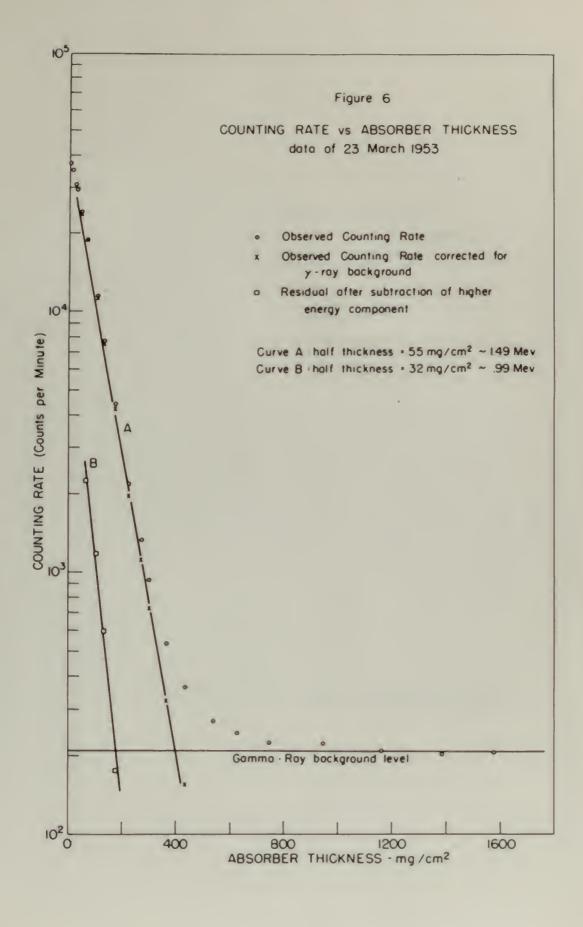


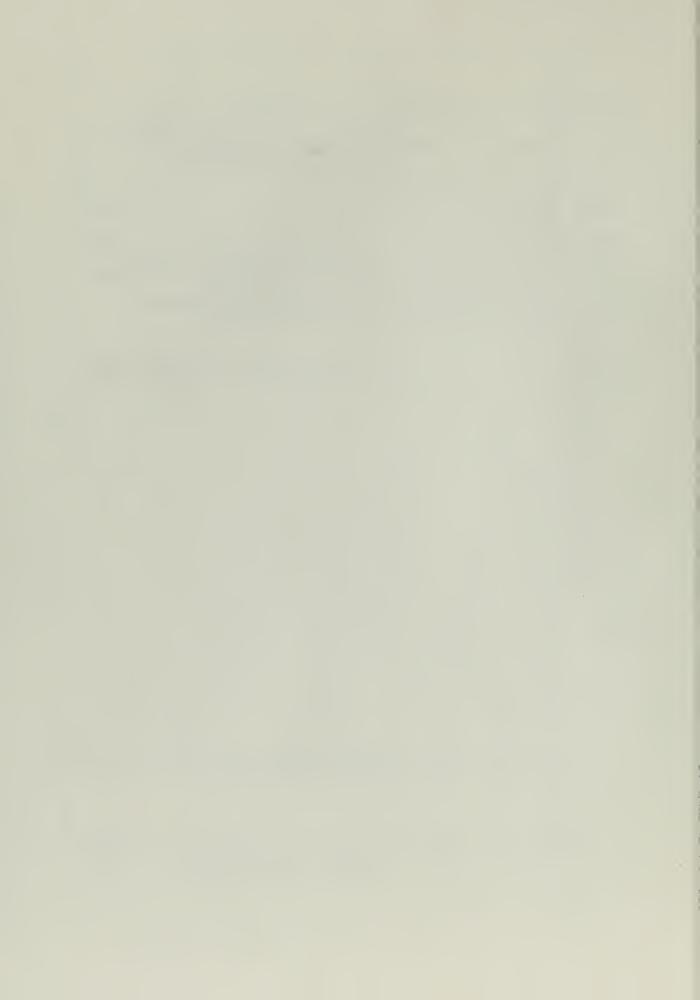


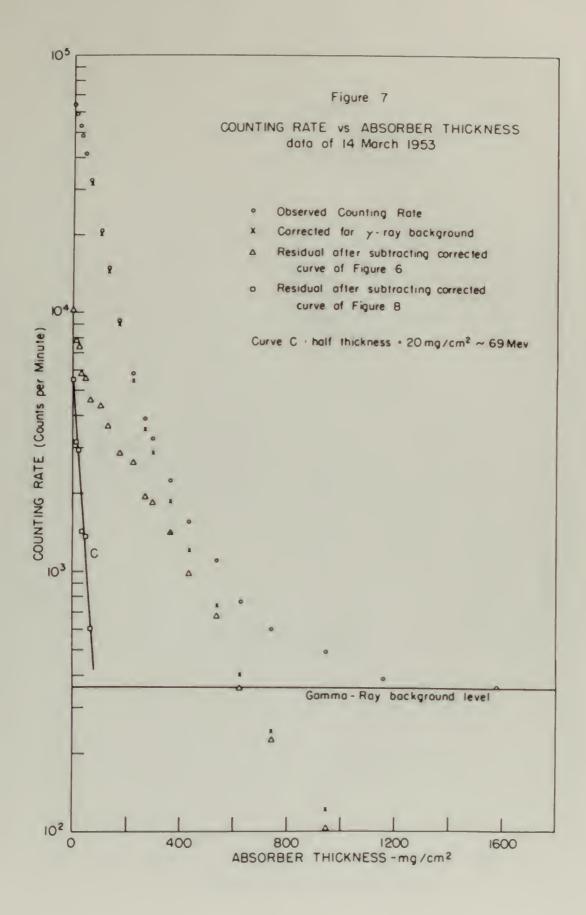
the 59 hour isotopes (Figs. 6, 7). The value obtained by this method for the 17.5 day isotope agrees with that found by the maximum range measurement stated above. The curve obtained for the 26 hour isotope (Fig. 8) was concave toward the origin and could not be treated by this method. A detailed discussion of the method and theory involved is contained in Chapter I of reference 22.

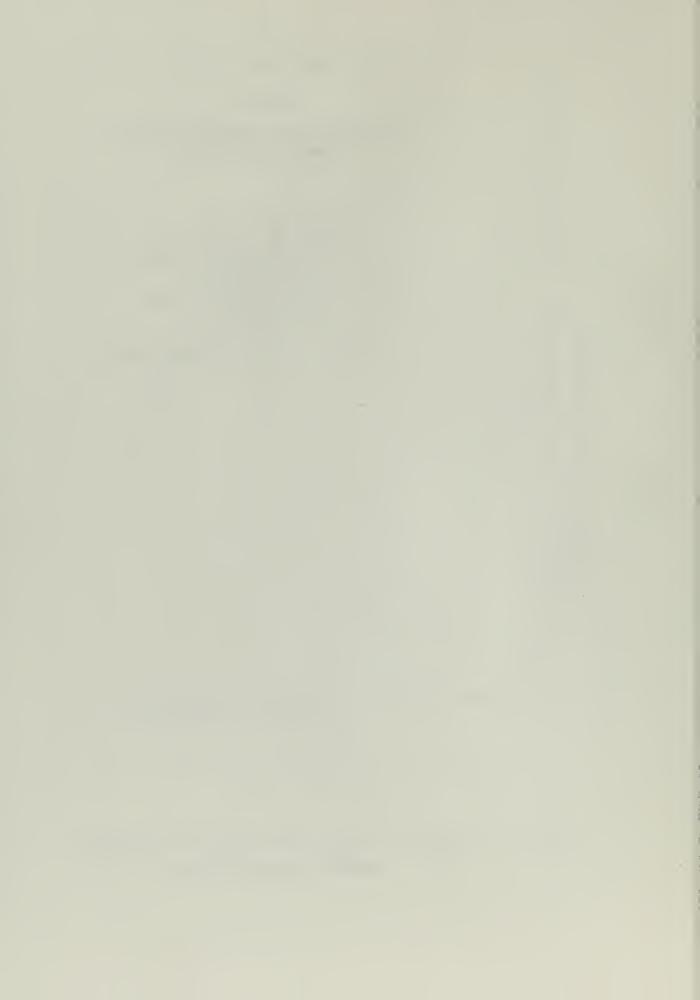
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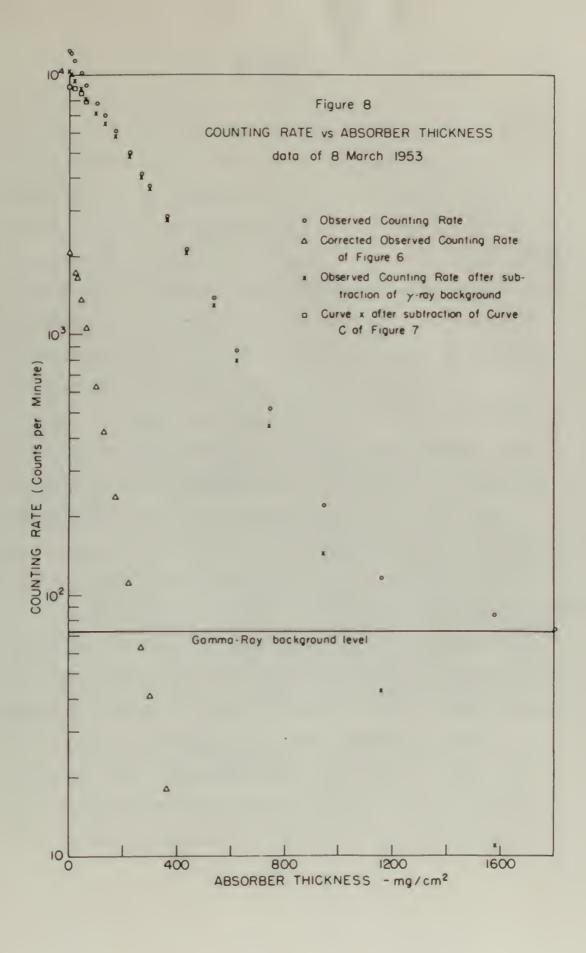
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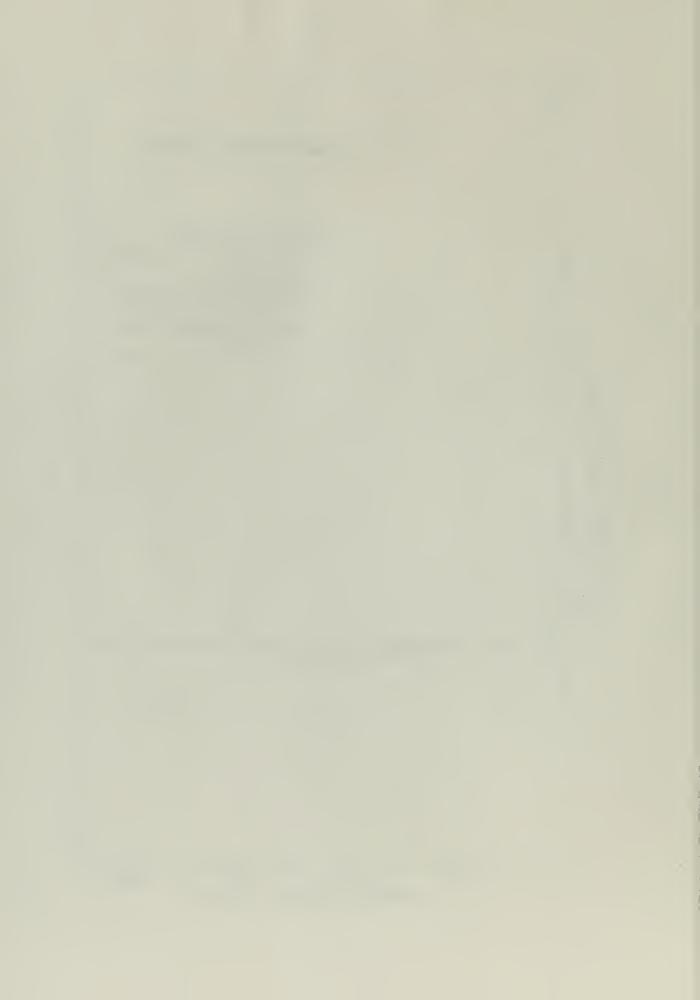












V. RESULTS

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l. The longest-lived isotope present in the mixture was detected by only the 4v counter. The half life was determined to be 82.9 \pm 9.2 days and by the filtering method described in Section IV A, the maximum β energy was found to be 0.11 MeV > E_max > 0.05 MeV. Since this isotope was not detected with the coincidence counter it is assumed to be a pure negatron emitter. This nuclide is believed to be As 73 due to the close agreement with the reported characteristics of that isotope. (11)

THE RESPECT OF LABOUR.

- 2. With 4π, coincidence, and end window counters a half life of approximately 17.5 days was resolved. Two β energies of this nuclide were determined by absorption measurements to be 0.99 MeV and 1.49 MeV. The close agreement of these results with those previously reported (9,11,19) seem to justify the assumption that this isotope is As ⁷⁴.
- 3. And window \$ counter measurements using an absorber thickness of 224 mg/cm² indicated that no isotopes were present having | energies > 0.7 MeV and half lives in the range 16.7 days > $T_{1/2}$ > 26 hours. Using lesser amounts of absorber a half life of approximately 59 hours was resolved. The only other half lives found to have this approximate value were 70.1 \pm 3.8 hours from 4% counter data and 48.5 \pm 1.8 hours from equincidence measurements.

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The latter value combined with the energy limitation previously specified justifies identification of this isotope as As 71. (10,11,12) The longer half life values obtained from 4w and end window counter measurements indicate that there is also present a negatron emitter having a T_{1/R} longer than 70 hours with energy < 0.7 Mev. The 70 hour half life determined from 4w counter measurements is believed due to a mixture of As 71 and As 77 assuming that the single reported value for the half life of the latter (20) is in error. This apparent discrepancy is worthy of future study.

- 4. From data of the 47 and end window β counters a component of half life 25.8 \pm 0.2 hours with a maximum β energy of 3.25 MeV was determined. A γ -ray energy of 0.85 MeV with half life approximately 29 hours was found from measurements made with the γ -ray scintillation spectrometer. These results confirm previously reported values (9,11,19) and identify this isotope as As 72 . This half life determined from coincidence measurements was 21.7 ± 0.2 hours.
- 5. There was no indication of the presence of the
 52 minute As 70 isotope (9) in the mixture. In addition,
 since no γ-ray energies > 0.85 MeV were resolved it was

The latter value consists the speep listening province of the previously specified province with lite value is leading to the list value of the late is an in the list with the value of the late of the late and winder consists of the late there is also provide a consist withing having a late the late the consist of the late that the consist of the late that the distribution of the receipt of the late of the late

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apparent that the 27.6 hour As 76 isotope having two reported y energies > 1 Mev (14, 18) was not present.

6. Tabular summary of characteristics of the mixture of radionuclides determined by this investigation.

Isotope	Hethod of decay	Energy (Mev)	T1/2	Thick target yield* (uc/uswp-hr)
As 71	8+	0.66	48.2 ± 1.2 hrs.	7.6
As 72	β ⁺ Υ'	3.25 0.85	25.8 ± 0.2 hrs.	64.9
An 73	p ⁻ 0	.11>E _{max} >0.02	88.9 ± 9.2 days	1.1
As 74	mala de	0.99, 1.49	17.82 ± 0.13 days	5.2
As 76		Not present in	the mixture	
As 77	0-	40.7	>70 hours 5 <	yield < 15**

^{*} The thick target yield values specified apply if the deuteron beam current was exactly 36 mamps and if the arsenic separation efficiency was 100 percent. Yield values quoted are based on \$ counting only and do not include orbital electron capture.

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 $[\]rightarrow$ Based on ratios of total β to β counting rates.

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1. Eagane, M.: Phys. Rev. 54, 140 (1936)

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- 2. Eagane, M.: Phys. ev. 65, 31 (1039)
- 3. Curtiss, B. R. and J. M. Gork: Phys. Rev. <u>53</u>, 681 (1938)
- 4. Bagane, R., S. Kojima, G. Miyamoto, and H. Ikawa:

 Proc. Phys-Math. Loc. of Japan

 11, 660 (1030)
- 5. Thornton, h. L.: Phys. Fev. 40, 107 (1936)
- 6. Walke, R.: Phys. Rev. 12, 660 (1037)
- 7. Sagane, H., G. Miyamoto, R.M. M. Ikawa: Phys.

 Nev. <u>50</u>, 904 (1941)
- 8. Glendenin, L. .: Sucleonies _, To. 1, 1 (1948)
- 9. Nopkins, F. H., Jr. and B. B. Cunningham: Phys. Rev. 73, 1406 (1948)
- 10. Hole, N.: Arkiv Mat. Astron. O. Fysik 36A, 1 (1948)
- 11. McCown, D. A., L. L. Mootward, and M. L. Pool:
 Phys. Rev. 71, 1315 (1940)
- 18. Bracher, D. F. and A. R. Crathorn: Nature <u>160</u>, 364 (1952)
- 13. Johansson, E., Y. Cauchois, and K. Biegbahn: Phys. Rev. 82, 275 (1951)

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- 14. Bair, J. E. and F. Walenscheln: Phys. Rev. 81, 533 (1951)
- 15. Strait, J. N., D. J. Van Patter, and W. V. Buechner:
 M.I.Z. Progress Report, January 1950
- 16. Jensen, 2. M., M. T. Sichols, and J. Clarent: Phys. May. 81, 143 (1951)
- 17. Shure, K.: M.I.T. Progress Report May 1981, and Thesis.
- 18. Mins, W. and H. Belban: Proc. Phys. Soc. (London)
 A64, 311 (1951)
- 19. Mei, J. Y., A. C. G. Mitchell, and G. M. Muddleston:
 Phys. Rev. 79, 8374, 19 (1980)
- Paper 54 (1950)
- 21. From mall, G. L., M. M. Maccofen, E. F. Mnite, and J.
 W. Irvine, Jr.: Progress Memort May 1953,
 Contract AT(30-1)-959
- 25. Goodman, C.: "Introduction to Pile Theory", Chap. 1,
 End edition, Addison-Wesley Press, Cambridge,
 Mass., 1989
- 23. Butement, F. D. J.: Mature 145, 149 (1950)
- R4. Brightsen, R. A., Shure, K., Fisher, C., and C. D. Coryell: Phys. Rev. 51, 2984 (1951)

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APPENDIX I THE 4v COUNTER

A. Description of the Counter

The 4 σ solid angle counter was designed as a convenient laboratory instrument to be used for the absolute standardization of β emitters. A photographic view of the disassembled counter, Fig. 1, illustrates the important features of construction and source mounting. Detailed specifications are given in Figs. 2 and 3.

The sensitive volume of the counter is geometrically similar to that of Caswell (1) and of Borkowski (2). The counter was designed and operated as a flow counter using n butane gas rather than as a fill counter due to the fact that the former is more stable with far better reproducibility (2). Since the counter must be opened each time a source is changed, use as a flow counter which eliminates the necessity for a vacuum seal greatly simplifies the operating procedure as compared with that of a fill-type counter. The 0-

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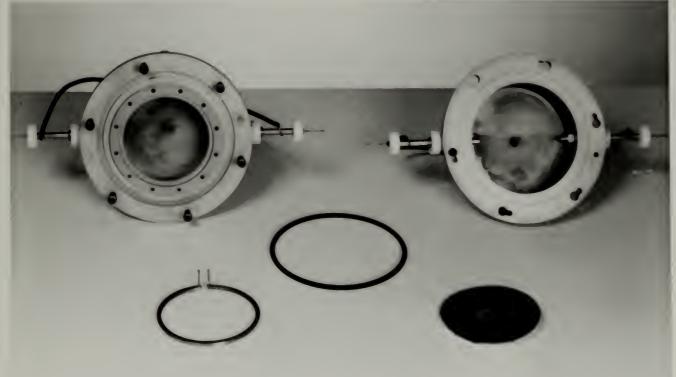
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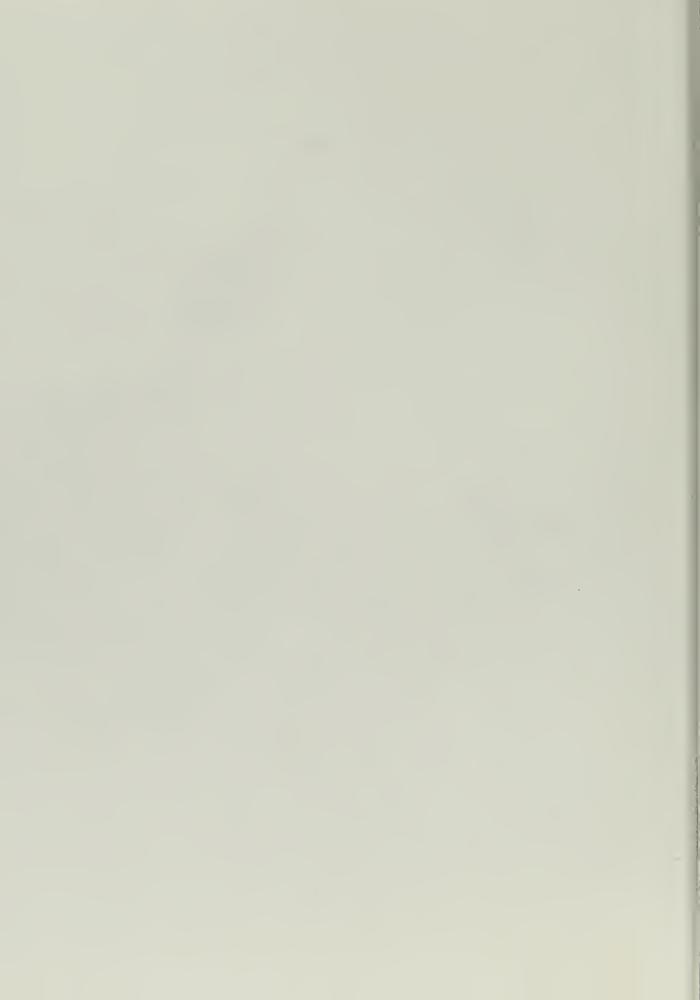
Fig. 1. Photograph of disassembled counter.

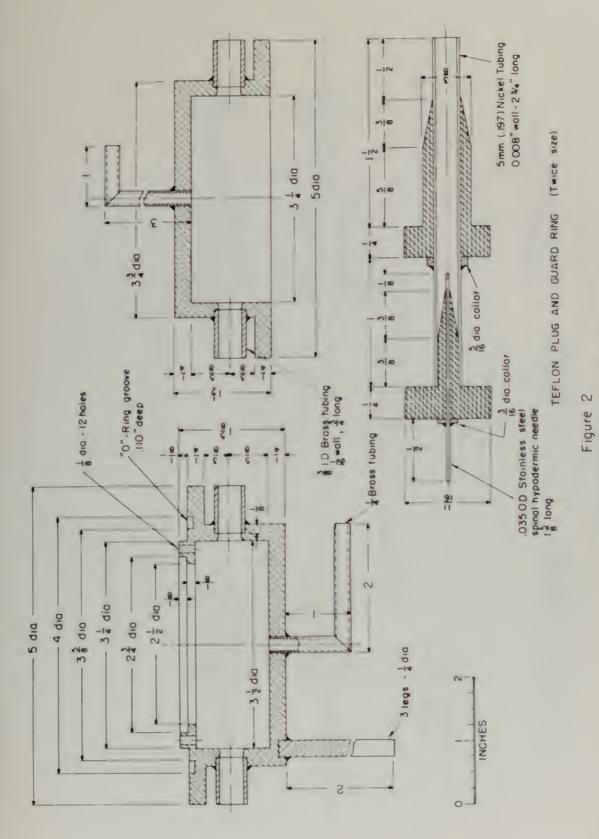
The upper view shows the source ring in place with the top half of the counter removed. The active source is the dark circular area in the center of the thin film which appears as a light area in the center of the source ring.

The bottom view shows the completely disassembled counter. The retaining ring for holding the source ring in place is shown with the removable handling pins in place.

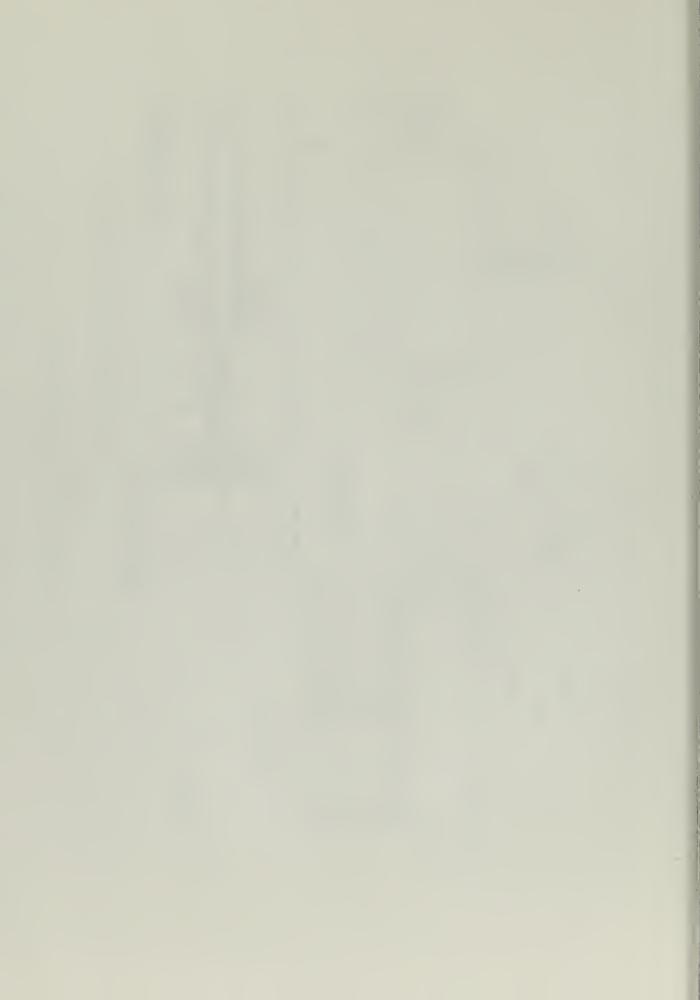


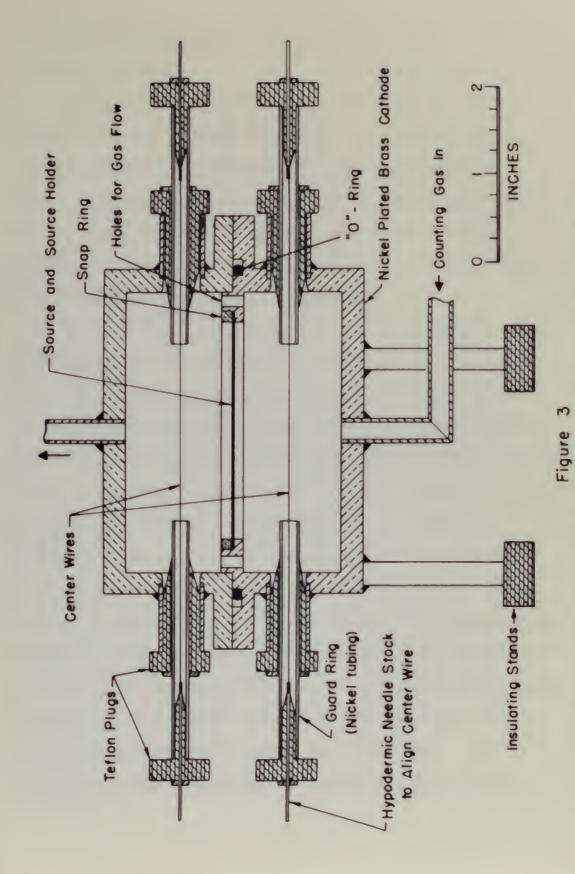




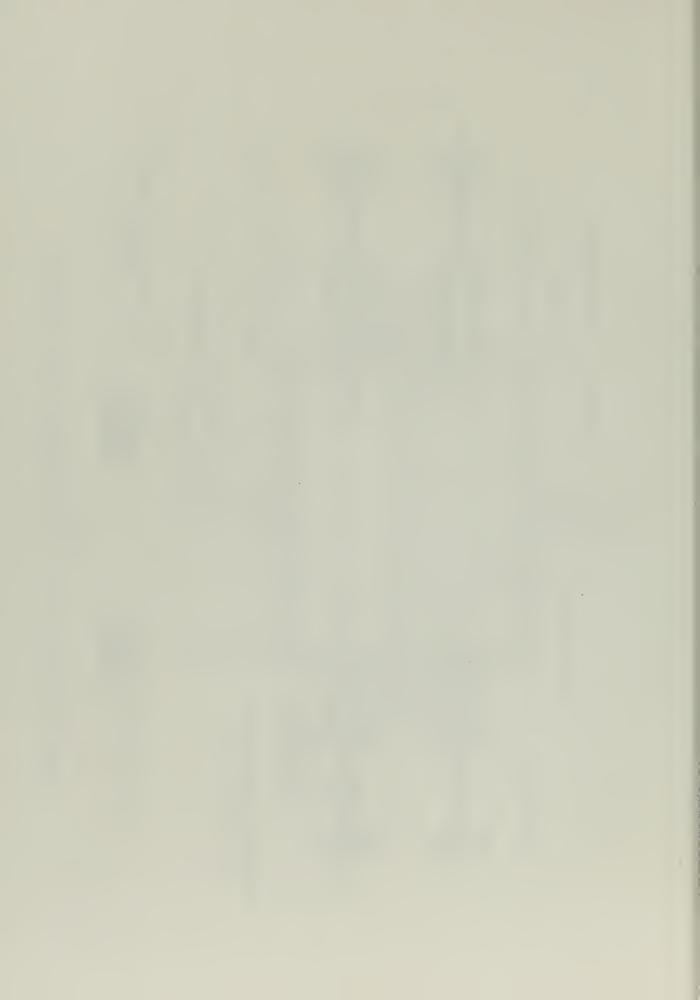


4 7 PROPORTIONAL FLOW COUNTER





CROSS SECTION OF 4 T PROPORTIONAL FLOW COUNTER



ring seal is used to reduce leakage of flow gas to an absolute minimum.

Squeeze-fitted Teflon plugs are used instead of Kovar glass for counter case-to-guard ring and guard ring-to-center wire insulation, with all insulator surface leakage paths designed for approximately 5000 volts. This feature is for convenience in assembly, cleaning of the sensitive volume, and to minimize the possibility of breakage in handling.

The 1/4 inch thick counter case is machined from 5 inch brass stock, all sleeve entries to the case being silver-soldered and the entire assembly nickel-plated to facilitate cleaning. Center wires of 1 mil tungsten are aligned by 20 gauge hypodermic needle stock to which they are soldered at the extremities. Center wires are guard-ringed with the guard rings at the same high positive potential as the center wires. The tripod legs supporting the counter fit into insulating stands made of drilled polystyrene rod stock. A grounded brass shielding box contains the entire counter assembly and minimizes externally-caused electromagnetic interference. Electrical connections within the box are made with rubber-covered wire insulated for 5000 volts. All electronic connections to the shielding box are made

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Ind 1/a luch thise counter must in machined from a inch press speci, all alcove antries to the aces being silver-soldered and the emitre escendig alokal-plated to facilitate eleming. Center wires of 1 mil tempeter are aligned by 50 gauge hypodormic mostle atom to which they are soldered at the extremition. Center wires are guard-ringed with the quark rings at the same high nomitive robustion as the counter wires. The tripod legs supportion the counter fit into inscinting exacts and affilian polystyrms and steer. I grouped breas whiching box contains was writer counter assembly and shielding connections within the box are made with values-covered wire insulated for 8000 roles. All sleetronds connections within the box are made with sleetronds connections within the box are made with sleetronds connections within the box are made with by coaxial cable and associated fittings. A U-tube oil-filled bubbler external to the shielding box maintains gas pressure within the counter slightly above atmospheric and avoids changes in gas concentration.

Three mil shim steel stock* provides a sturdy source mounting ring. The steel is first cut into 3 inch squares and a 5/8 inch hole is punched in the center of these squares. The 2 3/4 inch outer diameter is then obtained by use of a jig and ordinary paper shears. The prepared source ring is held in place in the counter by use of a split brass ring (similar to a piston ring).

To retain some of the pulse limiting properties advolute phylosola is being and on applicable of the conventional Geiger counter while eliminating STREET, SAFE PARTIES AND REAL PROPERTY. many of its objectionable features, the 4r counter is A SEATON . operated in the region of limited proportionality. (4, 5) The counter is operated at a well regulated 4300 volts STREET, STREET, SQUARE, DESCRIPTION OF PERSONS ASSESSMENT ASSESSMENT OF PERSONS ASSESSMENT ASSESSMENT ASSESSMENT ASSESSMENT ASSESSMENT with the cathode 2500 volts below ground and center nines the furthernor from a portiology in now life part wires and guard rings 1800 volts above ground to minimize corona and "spurty" noise effects. This operating No. booddepalling point is approximately 500 volts above the beginning the core is nowhight which precious of a counting rate plateau which is better than 0.6 Mild remarkly and dispercent per 100 volts. The center wire output is fed he summed unlast than her wide he private to a ruder or

^{*} Obtainable from Ward Uteel Co., Arlington, Hass.

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to a Model 100 amplifier through a cathode follower preamplifier (Atomic Instrument Co. Model 204-B) with the amplifier output driving an M.I.T. Model 400-R decade scaler. The counter with associated electronic equipment connected for normal operation is illustrated in Fig. 4.

B. Applicability to Absolute & Counting

emitted from a source in all directions, it has many advantages for measurement of absolute activity. First, since all particles emitted from the source are counted, a direct measurement of the \$\beta\$ disintegration rate is made without the need for precise knowledge of the solid angle with its accompanying scattering problems. Also, since the "efficiency for \$\beta\$ particles" is now loo percent, much smaller and thinner sources may be prepared thus reducing the self-absorption considerations. (8)

In the 4x counter, any \$ particle which produces an ion pair outside the source and source mounting will be counted unless this ion pair is formed in a region of low enough intensity that recombination occurs prior to

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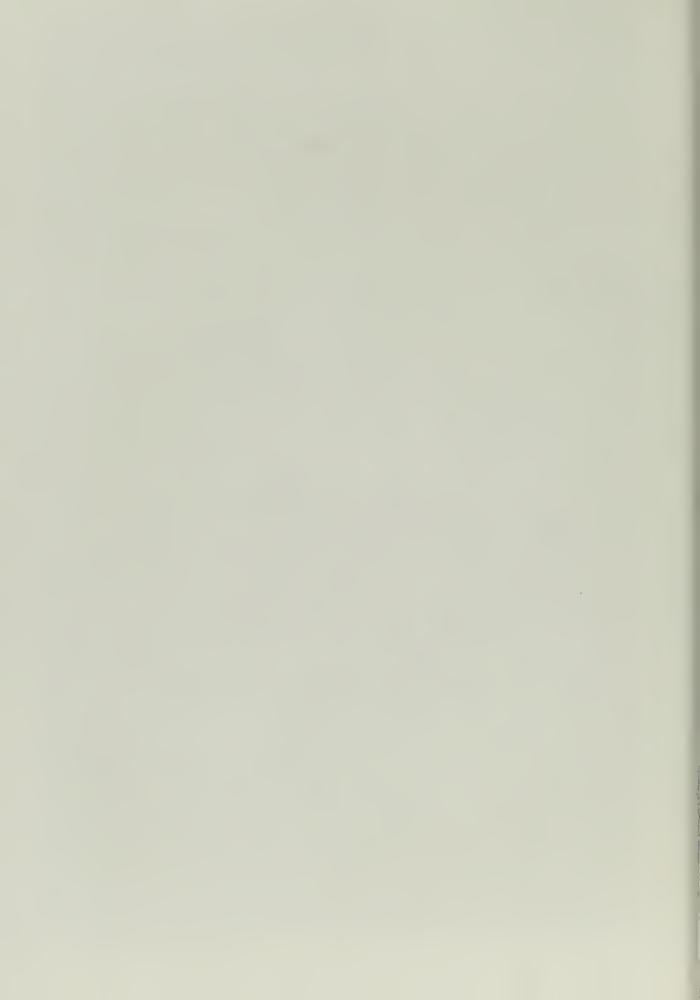
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Fig. 4. Photograph of counter with electronic equipment connected for normal operation.

The insulating polystyrene mounts are visible within the brass shielding box and the oil-filled bubbler is shown on the outside lower left corner.





initiation of the Townsend avalanche. Consideration of the geometry of and the fields existing in the sensitive volume indicates a very small probability for counting losses due to this effect. (1)

Any ionisation produced by internal conversion electrons, branched spectra, \gamma-ray spectra, and electrons produced in the counter walls or in the gas will serely add to the total ionisation per disintegration and will therefore be counted as a single pulse. This is also true of annihilation radiations and this fact was the 47 solid angle method valid for the assay of positron mitters.

Deviations from 100 percent absolute efficiency will be due only to (a) absorption in the source and source sounting film, (b) are a of low field intensity mentioned above, and (c) resolving time losses.

C. Important Aspects of Source Preparation

MITTERS AND ADDRESS OF PERSONS PROPERTY.

The preparation of a thin source is the most difficult problem involved in the practical use of the 4π counter. It is essential that the source be quite thin and uniform for any isotope emitting soft β particles. The

inditiation of the Impassed evaluation of the senting of the generalty of end the finites and the sentities volves indicated a very enall probability for counting leases due to this effect.(1)

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Deviations from 150 persons absolute efficiency will be due only to (a) obserption in the source and excess newsting Film, (b) ereas of les field intensity manifement above, and (c) resolving the lawses.

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The proparation of a tick compet to the most difficulty problem involved for the propient one of the de counter. It is essential that the roomes to quite tole and take form for our inches multiting mott 3 particles. The

chemistry involved in preparing uniform thin sources varies with the element involved. When a sample is simply allowed to dry, the active material has a tendency to crystallize out as one or more large particles or to dry in a thick ring of small crystals around the edge of the drop. Use of an infrared lamp speeds evaporation and reduces the tendency to "cluster" in every case attempted. It has been empirically determined that counting losses due to self-absorption can be neglected if the maximum solid content of the source is & 5 µgm for \$ energies > 0.6 Nev, but for B energies & 0.4 Nev solid content of the source should not exceed 0.1 ugm. These approximate values are based on a total pipetted source value of 0.085 ml. Within the specified limits, self-absorption losses are negligible compared to losses in the conductive layer on the source mounting film. Self-absorption can never be entirely eliminated by continued reduction of total solids since there is a finite particle size which the material must assume upon precipitation. It has been shown that below a certain very small concentration, a decrease in solids does not increase the observed counting rate. Also, a slight increase in solids above this value does not decrease the observed counting rate of a source,(3)

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D. Preparation of Source Mounting Film

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A solution made by dissolving 5 grams of stick parlodion* in 85 ml of amyl acetate was found to produce the most durable very thin uniform films. A period of about two weeks, with frequent agitation, is required for the formation of the solution.

Thin films are made by dropping an appropriate amount of the above solution on a clean surface of distilled water. The water used should first be boiled to eliminate dissolved gases and an indicator such as phenolphthalein should be added in order to check pH. Water which is even slightly acidic seems to decrease the physical strength and life of the film produced. A room should be chosen which is as dust- and draft-free as possible and a strong light is essential for inspecting the films and the water surface.

The simplest and most expeditious method is as follows:

- 1. Fill an 8-10 inch diameter culture dish to overflowing with the water prepared as indicated above.
- 2. Express two drops of parlodion solution on the clean water surface and observe the color display under a strong white light as the film spreads.

^{*} Obtainable from Central Scientific Co., N. Y.

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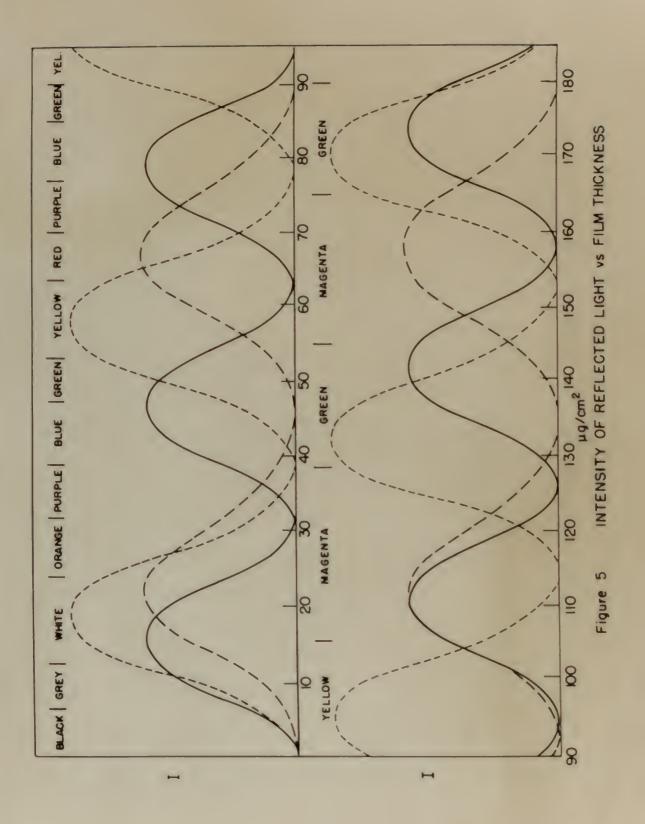
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- 3. hen maximum color display is evident near the edges of the film, drop the prepared source ring horizontally from a height of about 1/2 inch onto the center of the floating parlodion film.
- 4. Holding one edge of the floating source ring and attached film, trim away the excess film with a very sharp knife. The ring is then slid from the surface of the water at a small angle to avoid surface tension film breakage and may be placed vertically in a drying rack.
- of reflected color under white light and comparison with available curves which read directly in µgm/cm² (Fig. 5). For more accurate determination, the a thickness gauge may be used. This consists of a collimated source of polonium fastened to a movable micrometer jaw which is mounted vertically above a thin window Geiger counter. A zero reading of the end of the a particle range is made, after which the film is placed over the counter window and the measurements repeated. The distance between the two curves so obtained gives the absorption of the film in air-am, which can be translated directly into µg/cm². The gauge is capable of measuring thicknesses as small as 1 µg/cm² with less than 10 percent error.

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B. Conducting Layer for Source Mounting Film

For absolute measurements, it is essential that the collecting field within the counter not be distorted by the dielectric-covered hole in the source ring. A thin conjucting sotallic layer which covers the entire source support .. y be evaporated from a heated tungsten filment, the evaporation being performed in a vacuum of approximately 1 micron. To insure electrical contaot with the counter case, the layer should be deposited on the side of the source ring opposite that to which the periodion file adheres. The apparatus used for metallic evaporation is illustrated in Fig. 6 where the method of supporting the source ring described below is clearly visible. Since the grantest danger of file break go occurs in the set llie evapor tion process, this operation should be performed in or to pipetting the active source laterial.

For source solutions which do not contain hydrochloric acid, aluminum produces a suitable conducting layer and the following procedure is recommended.

1. Place the prepared source ring horizontally atop a length of 50 mm diameter glass or syrex tabing which encloses the prepared tungsten filement. The

For this late of the contract of the late the political of the continue are universely partnership and No the distributed covered bein in the series when a within most provided control of the control of the contract of nadequal sales a most before you and the depends owners PERSONAL TENNESSES AND ADDRESS of supposing all the same of the same statements to hard self the sounder treat into page or new and the post OR THE REAL OF THE SHAPE PERSON WITH THE WHILE THE WHILE THE WHILE THE the purishing this clauses. The opposite and the negatite improvation to tilburgaried in fig. 6 wasse Assirtated and species old authorized to Society with today he chierty while there are greatest despite of file brisings come in the organists of the all volve committee an officials on identica after automotic addressed newson swifes not galleright

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Fig. 6. Photograph of apparatus used in metallic evaporation.

The source ring lying on top of the cylindrical glass tubing under the bell jar is in proper position for aluminum evaporation. Tubing which carries cooling water for the filament electrodes is visible to the left of the bell jar.



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filament for a vacuum of 1 µ.

2. When a vacuum of 1 μ is reached, slowly increase filament current until the aluminum begins to evaporate from the filament. Observe the climb of deposited aluminum on the glass tube and when it reaches the top of the tube, shut off filament current. This procedure results in uniform conducting layers of from approximately 10 to 15 $\mu g/cm^2$ in thickness.

The hydrochloric acid in many source solutions will interact with the aluminum surface of the source mounting and frequently causes a decrease in counting efficiency. In such cases a thin layer (15-20 µg/cm²) of gold produces a suitable conducting surface. A standard microscope slide placed at the same vertical distance above the evaporating filament as the source mounting film and coated simultaneously with the source film provides a measurement of the thickness of gold. A resistance across the length of the slide measuring between 50 and 200 megohms indicates a thickness of gold between 15 and 20 µg/cm².

For the measurement of isotopes having β energies greater than 1 MeV, aluminum foil of 0.1 mil thickness*

^{*} Obtainable from Frank H. Caffin and Son, 32 Elm St., Hyde Park, Mass.

source ring should be approximately 7 on shown has

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rounding and frequently excess a decrease in counting artificiancy. In such assess a bid layer (16-70 pg/mg²) of ends produces a subtable conducting surface. A standard alcrossope alids placed at the seme vertical standard alcrossope alids placed at the seme vertical distances above the suspension filesean as the source and counting filesean as the source amount of the the county with the source of the source at the counting files and the source at gold, a resistance are nonement at the thickness at gold, a resistance are included the measuring the the standard at the standard at the standard at the standard of setumes to and the agency of the standard of the

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with no detectable counting loss. A fine mist of distilled water is denosited on the prepared source ring by use of an ordinary bulb type atomizer. The O.1 mil foil is then laid over the moistened source ring, carefully brushed flat with a fine camel's hair brush, and the excess trimmed off with scissors. If the above is carefully performed the foil is then inseparable from the source ring and parlodion film.

No conducting layer need be applied to the source mounting if a high degree of accuracy is not required. Elimination of the metallic layer results in counting losses of from approximately 1 percent to 3 percent depending on the maximum β energy of the isotope used. For example, the observed counting rate from several non-conducting P^{32} sources increased by $\frac{1}{2} \pm 0.5$ percent with the addition of either foil or evaporated aluminum conducting coatings.

F. Preparation and Precipitation of Source Material

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1. Isotopes emitting a particles of > 0.6 Mev.

The best method found so far consists of adding

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a small amount of Jentonite, a colloidal mud, to the pipetted drops of Lource solution. The source ions are adsorbed on the Sentonite which dries in a fairly uniform layer of fine particles. Microscopic observation of sources prepared in this manner yields a typical size of 1 micron for the largest particles, i.e., 0.1 mg/cm² for material of density 1. (1) The layer is much more uniform if instead of simply allowing the source to dry, an infrared lamp is used to decrease evaporation time.

Using the highest specific activity source material available to minimize source solid content, a solution of from 1 to 1.5 µe/ml is prepared. This yields approximate counting rates from 55 × 10³ to 80.5 × 10³ dpm per \$5\$ of active material. Since the resolving time of the counter is approximately 0 µsec, this range of activities limits resolving time losses to \$2 percent.

In solutions of materials of high specific activity, considerable losses may be caused by adsorption of the active constituents on the walls of containing vessels and pipettes used in measurement. (8) This effect results in a decrease of activity in solution, especially

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for carrier-free materials. This loss of activity may he reduced by the addition of inactive isotopes of the same chemical form as carriers prior to preparation of the source solution. For example, a small cuantity of KH2PO4 is used with solutions of carrier-free P³² and KI is used with carrier-free I¹³¹. The mass of carrier which may be added is determined by the per-issible solid content of the solution but a desirable ratio to make adsorption negligible is approximately 10⁶ inactive atoms per active atom.

The pH of the active solution is maintained so as to keep the active atoms in solution. For some isotopes the solution should be acidic while others require a basic solution. A general rule which has few exceptions is to prepare an acidic solution if the active atom is in the cation and a basic solution if it is in the anion. (8) In all solutions, any substance added to adjust the pH must be soluble when combined with the active material in order to prevent precipitation.

The following procedure is recommended for the actual source preparation:

on the center of the 5/8 inch diameter metallic coated parlodion file. The micropipette should be rinsed twice

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onto the source ring in order to remove all active
material from the pipette. It has been experimentally
determined that the following percentages of active
material are contained in rinses of the pipetter

lst rinse — 3 percent of initial contents

2nd rinse — 1 percent of initial contents

3rd rinse — 0.5 percent of initial contents

Micropipettes used in source proper tion must be calibrated with mercury since deviations of 1 percent

from labeled volume are not uncommon.

b. If several sources are to be prepared at a time, the vicuum trap arrangement illustrated in Fig. 7 is indispensable. After each source (consisting of one pipette volume plus two rinses) is expressed, the pipette must be thoroughly elemed and dried prior to preparing the next source. Using the vacuum trap arrangement the pipette can be classed with an inctive corrier solution followed by flushing with pure distilled water and then dried by the sir stream pulled through the pipette. The total operation of cleaning and drying requires less than 3 minutes with this apparatus.

e. Express 10% of Bentonite solution (approximately 25 mg Bentonite/=1 H₁0) into the trop of source ** Obtainable from Madiation Counter Lab., 1884 %. 21st St., Chicago, Ill.

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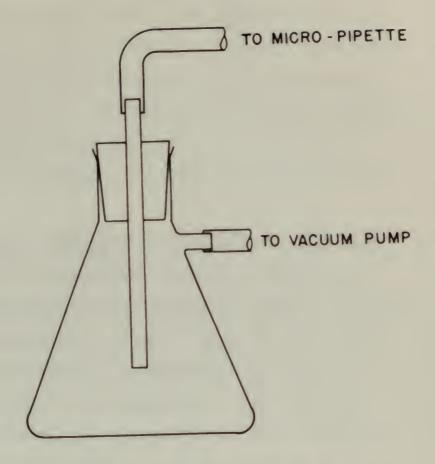
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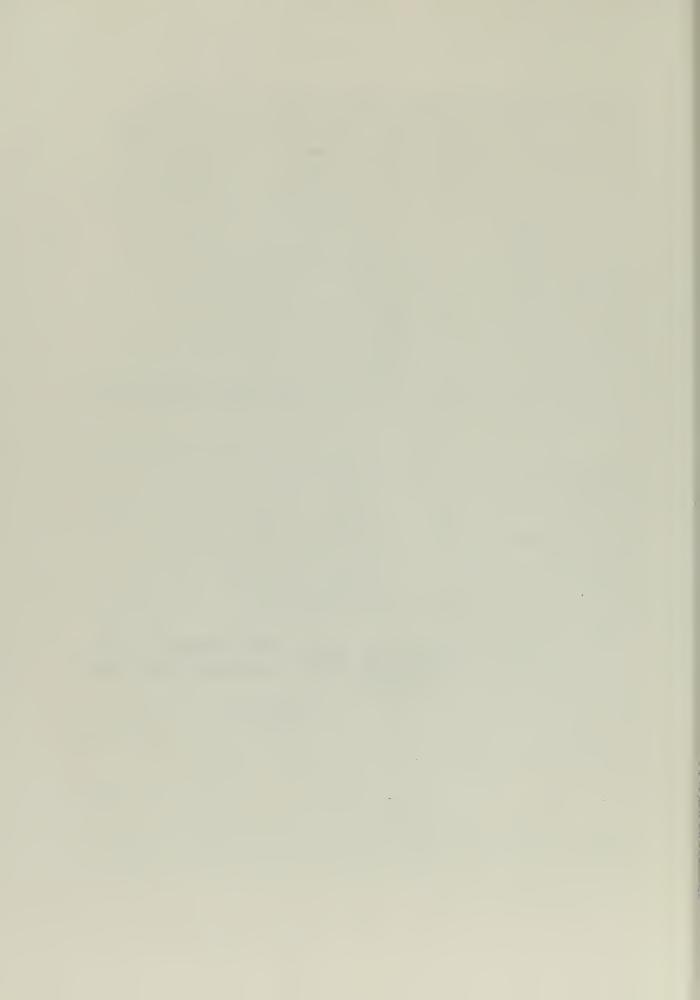
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VACUUM TRAP ARRANGEMENT FOR CLEANING AND DRYING PIPETTES

Figure 7



solution previously formed.

- d. Thoroughly disperse the Dentonite in the source solution using an air jet produced from an eye-dropper which has been flame-drawn to a fine capillary point. A strong light facilitates visual observation of the mixing which is complete when the entire drop takes on a cloudy appearance.
- e. The prepared source is then dried under a heat lamp.
- In order to minimize self-absorption losses
 in the measurement of soft 3 particles extreme care must
 be taken in preparation of the thin source, es scially
 if the isotope solution is a chloride which tends to
 form large crystals on precipitation. The following
 procedure, applicable to preparation of Co⁶⁰ sources,
 is cited as an example. (6)
- a. Using ${\rm Co}^{60}$ of high activity (approximately 1 curie/gram), dilute to proper operating range using redistilled ECl. The solid content of ordinary HCl often exceeds the solid content of the source material. The carrier concentration should be of the order of 3 mg of ${\rm CoCl}_2/{\rm liter}$ giving a total solid content in a 25% aliquot of 0.075 μg .

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b. After pipotting the required amount of active solution on the source file, evaporate the Co⁶⁰ to dryness as CoCl₂ in order to get rid of the MCl. Then add a drop of water to the evaporated material to redissolve the CoCl₂.

c. Wig, introduced as MigOH in a beaker, should be used to precipitate the cebalt which should cover the entire area of the original water drop quite uniformly.

cator with sodies hydroxide used as a sesiceant. A

Co⁶⁰ source carefully prepared as outlined above will

reduce self-absorption to the minimum value known to

be obtainable at this time.

G. Technique Used in Absolute Counting

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Normally three sources are propared as outlined in Section F from each solution to be counted. Comparison of counting rates of the three sources gives a seasure of the precision in source preparation. 'It's a little

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practice the difference between sources due to all errors involved in preparation may be maintained at < 1 percent.

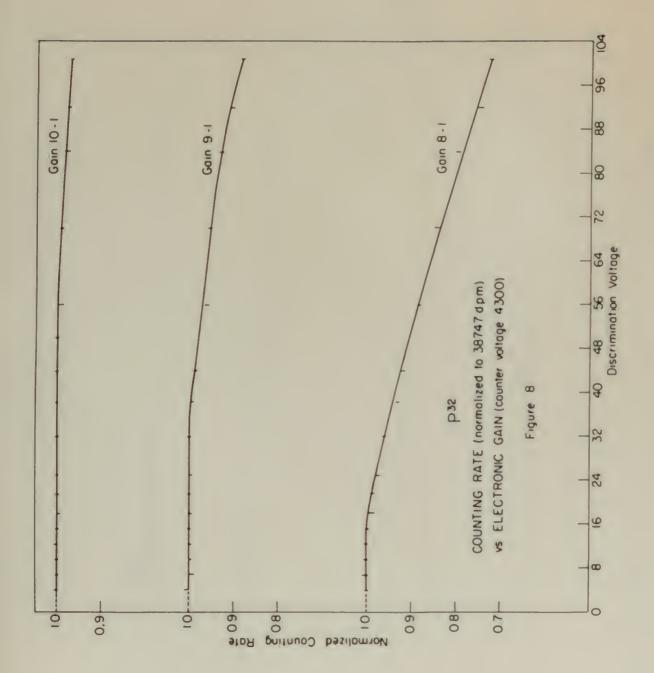
2. Counting procedure.

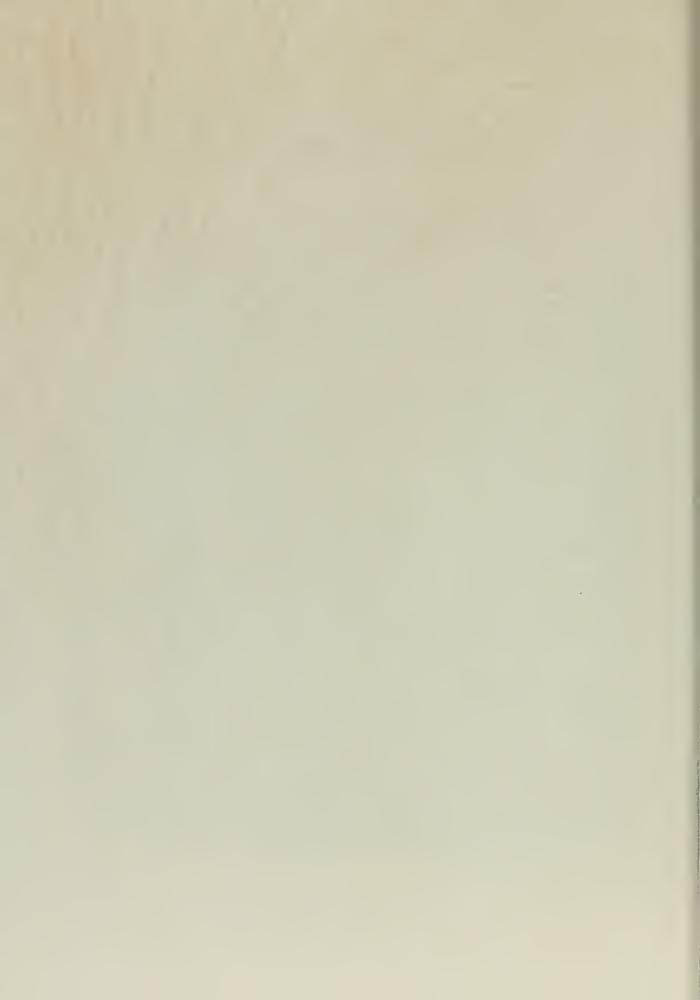
Background counts are taken before (and after if necessary) each run by inserting a plain shim steel disc in place of the source. Two comparison tests are made on all measurements made with the 4s counter. First, with counter voltage fixed at 4300 volts, integral discriminator curves are plotted for gain settings of 10:1, 9:1, and 8:1. The latter two settings each decrease electronic gain by a factor of approximately 2 (Figs. 8 and 9). Secondly, with electronic gain held constant at 10:1, integral discriminator curves are plotted for counter voltages of 3900, 4100, and 4300 volts (Figs. 10 and 11). If in both cases the discriminator curves are flat over a discriminator range of > 10 volts (Fig. 12), we can assume that all \$ particles emitted into the sensitive volume are being counted. Figures 9 and 11 which are typical of Co clearly indicate the high percentage of collection and may be compered with Figs. 8 and 10 which are typical of P32. The method of extrapolation to determine the true

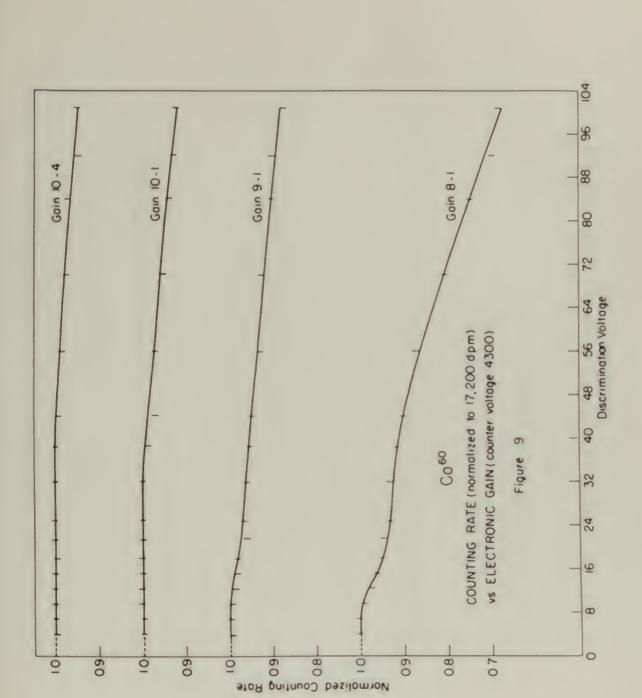
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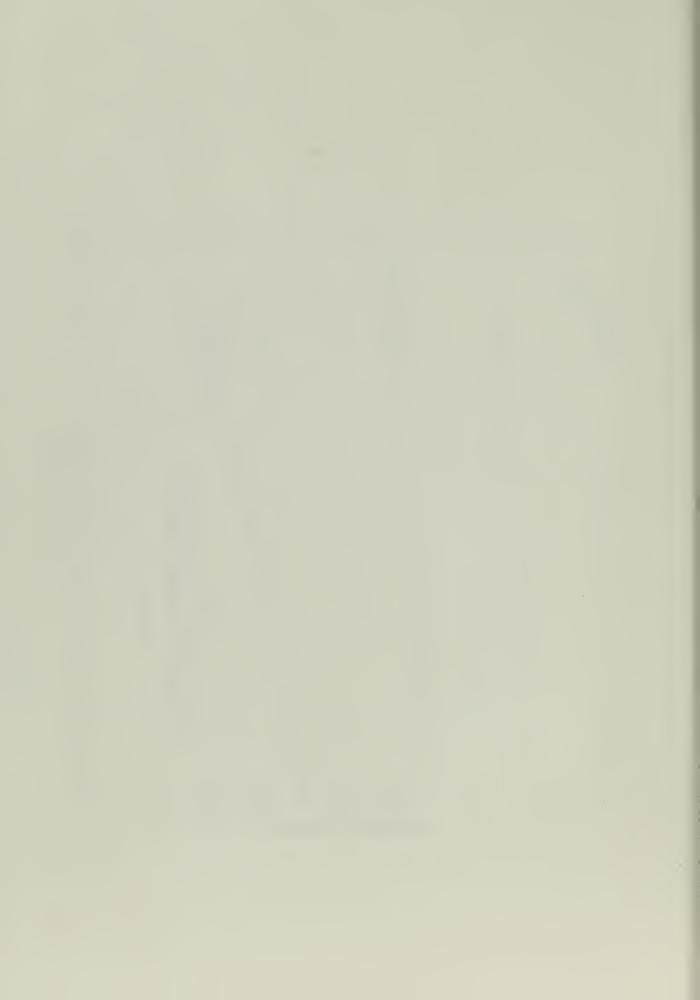
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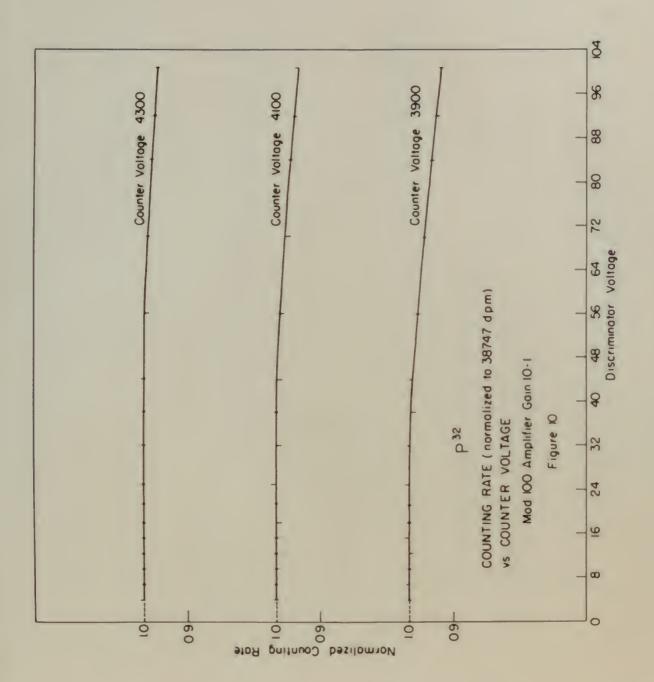
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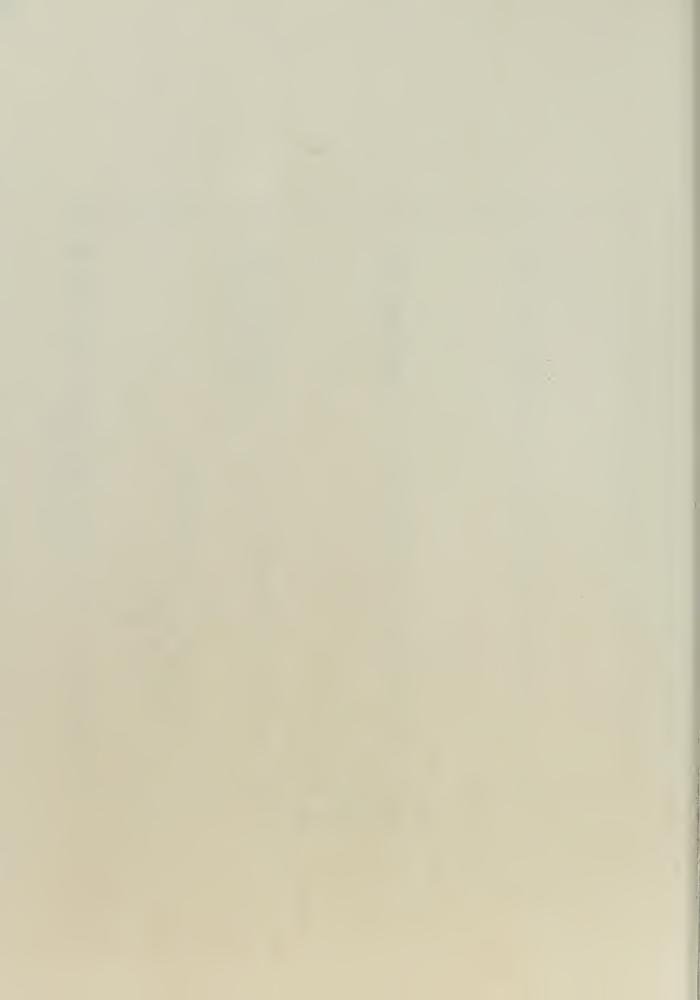


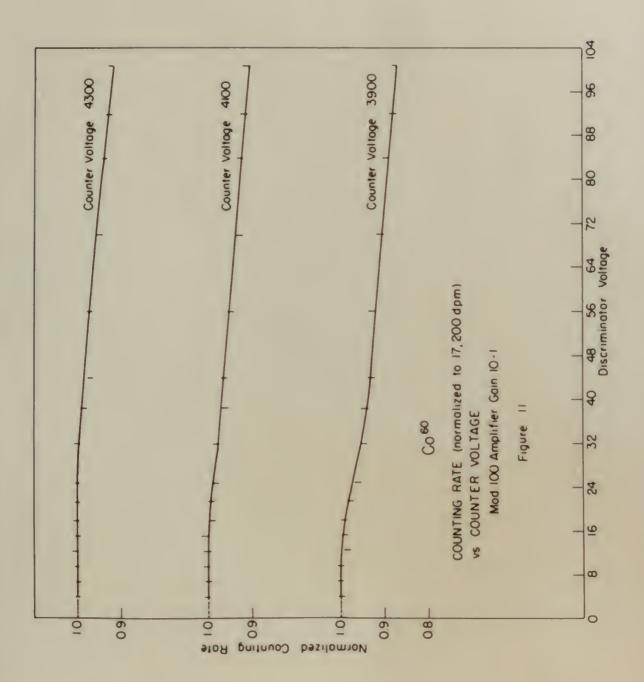




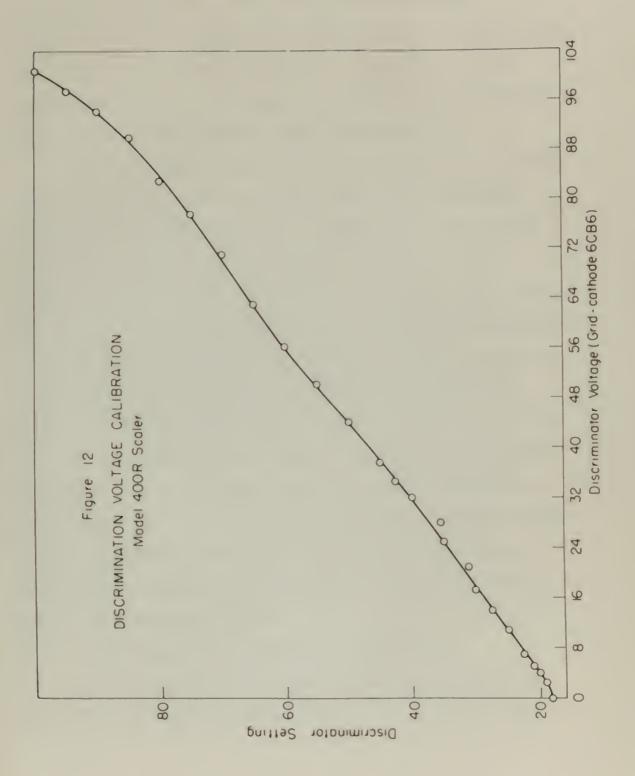


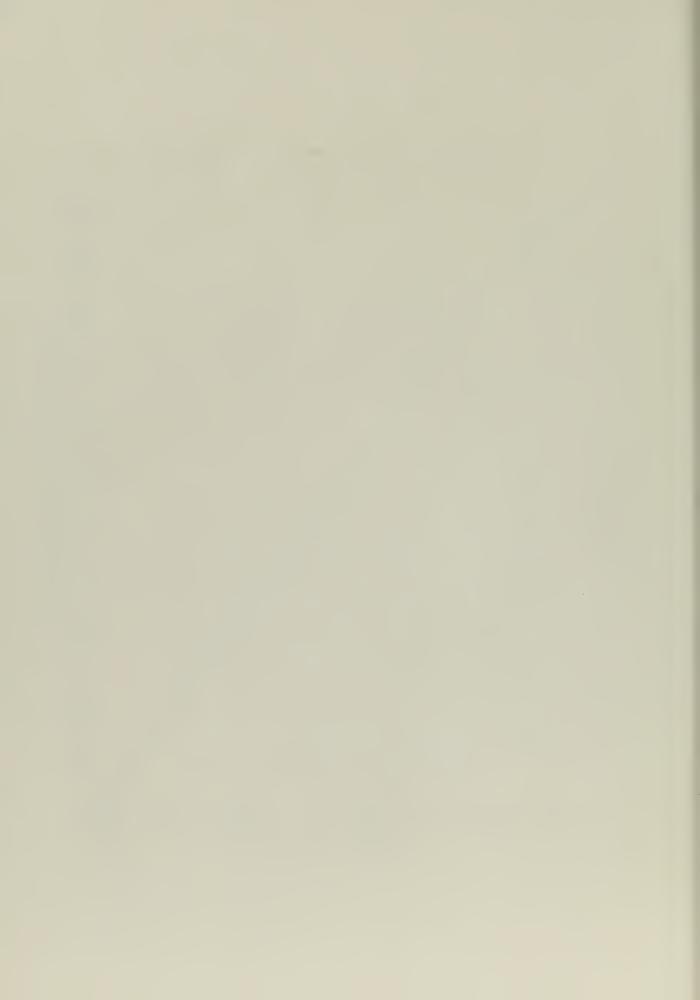












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disintegration rate is indicated on all curves. A
further check to verify proper operation is a statistical
analysis of the counting rates for points on the discriminator plateau. The mean value thus obtained should
agree with the extrapolated true counting rate.

has been determined for a given isotope the counting procedure is si-plified. The discriminator may then be set at the midpoint of the voltage plateau and with counter voltage set at 1000 volts and an electronic gain of 10:1, a series of runs is made. A st tistical analysis of these runs is then made to insure that the counter is operating properly and the observed counting r to is determined by the mean value thus obtain a.

An electronic gain of 10:1 is chosen as the normal operating point. At this value the largest sulses in the counter just overarive the Model 100 amplifier without causing counting losses, and the smallest pulses are sufficiently larger than noise to be detectable over a useful discriminator range.

3. Correction to observed counting rate.

the ever go background is subtracted from the mean value of the measured counting rate, to yield F_0 ,

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Once the spinger of the discrimination plates in the counting the back has been department for a green increase and then consider the first midgoing of the voltage plates and with death at the midgoing of the woltage plates and with deminer willings set at diff welts and an electronia main at 10x1, a series of room in mode. I stratetical confests of these room is then made it attraction to electronia the operating property and the character that the counter the determinant property and the constant to strategy and the determinant of the trace of the contract that the counter the determinant by the case that the counter the determinant by the case that the counter the contract of the case that the counter the case of the case that the case of the case that the case of the case that the case of the case of

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3. Derrowthen he seement assetted rates

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the observed counting rate. For counting rates \leq 60,000 dpm, this value may be used as $E_{\rm t}$, the true dislategration rate, if an error of 3 percent is accortable.

depending on the degree of recision desired:

a. Correction for resolving time lower. If No and NA are defined respectively as observed and extent disintegration rates, then

$$x_{\lambda} = \frac{y_{0}}{1 - y_{0}t}$$

when t is the count resolving time which has been letermined to be approximately 90 ps.c.

nounting file. If it is desired to make this correction, then at the same time the source positings are present, cover layers of parlodion file of the same thickness should be prepared on source rines awing central hole of 1 3/8 inch limeter. The conducting file evapor tea on these cover layers should be of the same thickness is that deposited on the ring containing the active source.

actual counting rate. Then remove the source ring,

 $\label{eq:condition} \begin{aligned} & \text{conjugates substantial su$

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carefully place the ring containing the cover layer directly over the source to form a somewich. With this sandwiched source in place, as in measure NA. The percent go difference in NAT and NAT should be quite close to the true correction for absorption due to the counting file.

A slightly more accurate determination of absorption in the mounting film (7) is moted below for completeness.

"Experiments have been conducted to determine the amount of absorption, if any, due to the film between the source and the lower half of the 4s counter. The number of particles counted by the top half of the counter connected separately will be

$$H_{\text{top}} = \frac{M_{0}}{2} \left[1 + B_{p} + (1 - T) B_{M}(b) \right] \tag{2}$$

where No is the true disintegration rate of the source,
Bris the percentage becautering from the file, is
the fractional absorption in the file, and Ly(b) is the
percentage bac scattering due to the file in the ottom
helf. The number of particles counted by the bottom
helf connected separately will be

$$N_{\text{bottom}} = \frac{n_0}{2} \left[(1 - 7) + (1 + B_0) B_0(t) \right]$$
 (*)

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unrefully place the ring symboling the cover layer directly over the source to form a mandricks. While this send-vision secure in glace, exits steered by the secretary in glace, exits steered by the secretary to the steeresting the shootyping our to the secretary our steeresting this.

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"Experiences have been continued to the file between the number of the process of the file between the number of the sources and the the the the int the sounces of puritions counted by the the top helt of the counter sounces connected will be

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*From symmetry considerations $B_{V}(t) = B_{V}(b) = B_{V}$.

*The factor B_{T} can be neglected when the film is thin and of low atomic number, so that (1) becomes

$$N_{\text{top}} = \frac{N_o}{2} (1 + B_W - \tau B_W) \tag{3}$$

In the bottom half, again assuming $B_p = 0$, one obtains

$$N_{\text{bottom}} = \frac{N_o}{2} \left[(1 - \tau) + B_W \right] \tag{4}$$

Putting this in the form y = ax + b gives

$$N_{\text{bottom}} = \frac{-N_0}{2} T + \frac{N_0}{2} (1 + B_0).$$
 (5)

With the thin films under consideration it can be assumed that the absorption is directly proportional to the film thickness. Equation (5) can be used to determine the absorption correction graphically. A more direct method of determining 7 can be deduced from eq. (3) and (4).

$$N_{\text{top}} - N_{\text{bottom}} = \frac{N_{\text{o}}}{2} \tau (1 - B_{\text{W}}). \tag{6}$$

The actual counting rate observed with top and bottom habes connected together is

$$N_{\rm tb} = N_{\rm o}(1 - \tau/2)$$
 (7)

so that (6) becomes, if one lets Ntop - Notton = \(\triangle \)

"The following constitutions of the case the file is that the and of low about number, so that (1) received

In the botton half, equin essenting $B_{\mu}=0_{\mu}$ one obtains

$$\left[\mathbb{Z} + \left(T + I \right) \right] \frac{1}{D_{ij}} = \mathbb{Z}^{2 \times 2} \mathbb{Z}$$

PARTIES THE REAL PROPERTY IN AN A SECTION.

entry the rich films under equalisation is was an appearance to agree the more than abstraction is arrest and the parameter that this was the abstraction (b) can be used to determine the washing nearestant contraction grantming. A more direct material of interest material of interest material of interest material of interest materials.

The actual counting outs observed with top and better higher countries bageiner in

A want (d) because if one law west - Louisian a

$$\tau = \frac{N_{\text{top}} - N_{\text{bottom}}}{N_{\text{tb}} - N_{\text{bottom}}} = \frac{\triangle}{N_{\text{tb}} - N_{\text{b}}}, \quad (8)$$

STREET, SQUARE,

and similarly

$$B_{V} = \frac{N_{top} + N_{bottom}}{N_{tb}} - 1. \tag{(7)}$$

The absolute counting rate is then obtained by substituting (8) into

$$W_0 = \frac{W_{tb}}{1 - \tau/\epsilon}.$$
 (10)

"Thus by taking three different readings of the same source on a single film it is possible to determine the absorption by the film. This proves extremely useful for low energy \$ particles."

c. Corrections for self-absorption and backscattering due to finite source thickness. In general
the sources prepared are very thin compared with the
half thickness for absorption in source material.
Since the resultant self-absorption and backscattering
corrections are small (usually < 1 percent), approximate methods may be used to compute these corrections.
The average source thickness is computed from the source
area and the known mass of material contained therein.

Self-absorption may be estimated as follows:

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The average source thickness is computed from the sourcest was a few and the sourcest with the sourcest with the sourcest and the sources

Let t = half thickness for 3 in source material (in ug/cm²)

x = average source thickness (in μg/cm²) then the true activity N. is related to the observed activity M, by

$$N_A \simeq \frac{N_t}{\overline{x}} \int_{0}^{\overline{x}} (\frac{1}{p})^{(\overline{x}/t)} d\overline{x}$$

$$N_{A} \simeq \frac{N_{t}}{\overline{x}} \int_{\overline{x}}^{\overline{x}} \left(\frac{1}{2}\right)^{(\overline{x}/t)} d\overline{x}$$

$$\frac{N_{A}}{N_{t}} = \frac{t}{\overline{x}} \left[\frac{1 - (\frac{1}{2})^{\overline{x}/t}}{\ln x}\right] = \frac{1 - (\frac{1}{2})^{\overline{x}/t}}{0.693 \frac{2}{\xi}}$$

and
$$\frac{N_A}{N_t} \simeq 1 - (0.346)^{\frac{1}{2}/t}$$
 for $\frac{1}{2} \ll t$

If desired, backscattering corrections may be approximated from the results published by Zumwalt. (9) In these corrections it is assumed that when the source mounting material is very thin, the percentage of saturation backscattering obtained is a function only of its thickness in terms of absorption half thickness. With this assumption, the Zumwalt data obtained for colystyrene can be applied to parlodion by comparing relative half thicknesses involved.

There is also a small loss for particles which travel transversely through the film and are absorbed Catharan seemen at 1 was marrial at apart of 2 and (Anthon at)

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before emerging. An order of magnitude approximation of this loss can be made by consideration of the solid angle within which particles will traverse one half-thickness of the film before emerging. For P³² (assuming a half thickness of about 100 mg/cm²) this gives, for a uniform film 0.05 mg/cm² thick:

$$\varepsilon \Omega \sim \frac{2\pi \times \frac{0.05}{100}}{4\pi} \simeq \frac{1}{4000}$$

where $\delta \Omega$ = the fraction of emergent particles which traverse a path \geq one half-thic ness of the film, which is negligible. For softer particles, t is correction by be large enough to require consideration.

H. Important Characteristics of 4r Counter

Counter voltage plateau: begins at 3700 volts, slope < 0.6 percent per 100 volts.

Settings for normal operations

Counter voltage: 4300 volts

Cathode: P500 volts below ground, 600 volts supplied by batteries.

Center wires and guard rings: 1800 volts above ground.

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Instrument Co. presentifier Model 1040):

Conrse gain: 10

Pine gain: 1

Nesolving time: 50 ± 5 µsec (determined by a series of measurements by the two-source method)

n-butane flow gas rate: approximately 2 bubbles/sec

Flushing time required for at ble operation: 20 min

Length of discriminator rates (at normal operating settings):

Counter officiency:

 ${
m Co}^{60} \simeq 87$ percent (due to high solid content of available Co activity)

1¹³¹ > 98 percent p³² > 99 percent

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- 1. Caswell, R. C.: Ph.D. Thesis, "A Study of the Average Energy of β-Rays," MIT (1947).
- 2. Borkovski, C. J.: Conference on Absolute 3-Rey Counting, National Bureau of Standards, July 13, 1949.
- 3. Seliger, H.: Private communication, 1953.
- 4. Rossi, B. B. and H. H. Staub: Ionization Chambers and Counters, McGraw-Hill Book Co., N. Y., 1939.
- 5. Brown, 5. C.: "Theory and Operation of G-M Counter",
 Nucleonics, 2, 10 (1948); 3, 50(1948); 3, 46 (1948).
- 6. Seliger, H.: Private communication, 1953.
- 7. Seliger, H. and L. Cavallo: "The Absolute Standardization of Radioisotopes by 4# Counting", J. Research Natl. Bur. Standards, 1,41 (July 1951).
- 8. Putnam, J. L.: "On the Absolute Measurement of βEmitters", United Kingdom Atomic Energy
 Research Establishment AERE-NR-318, 24 February
 1949.
- 9. Zumwalt, L. R.: United Kingdom Atomic Energy Research
 Establishment, MDDC-1346. (Reproduction of
 curves contained in reference no. 8).

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10. Houtermans, F. G., L. Heyer-Schutzmeister, and
D. M. Vincent: "Energy Calibration for
4w Counters", Z. Physik. 1, 134 (1952).

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APPENDIX II

THE ECINTILLATION Y-RAY SPECTROMETER

The counter consists of a sodium iodide thallium activated crystal 4.3 cm in diameter and 5 cm long mounted on an ACA type bell photomultiplier tube. The gain of the linear amplifier used is adjusted so that the spectrum is always represented by voltage pulses of from 0 to 100 volts. A single channel differential pulse height analyser, fed by the linear molifier, drives a precision counting rate meter of variable time constant and full-scale sensitivity of from 200 to 20,000 counts per minute. The discriminator base line is varied continuously from approximately 0 to 100 volts and a window of 2 volts is used for all observations. Calibration runs were made before and after obtaining each set of data by use of y-emitters of known energy.

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APPENDIX III

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THE END WINDOW COUNTER

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A. Description of Equipment

tub * in a set of calibrated all inum ab orbers. **

The tube is neutred in a shielded maple changer***

which contains diding trans for ecur to positioning of source an absorber.

B. Experimental Technique

CONVESTIGATE OF TRANSPORT SHALL

1th a source inserted on the lo or tray under the Geiser tube ecunting rates were recorded for various thicknesses of absorber contained on the upper tray.

Direct their supposition for suchless promptions.

- * Tracerlab, Inc. Model TG-C. Geiger Tube, window thickness I mg/cm?.
- Tracerlab, Inc. Type N-3A Calibrated Absorbers.
- Tracerlab, Inc. Model EC-90 Shielded Manual Sample Changer.

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N. Emphysionical Production

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Counting procedure varied depending upon the thickness of absorber. At high counting rates, the number of counts per 1 minute interval was recorded for at least three intervals. At intermediate counting rates, the preset count feature of the scaler was utilized and the time required for 10,000 counts was recorded. At very low counting rates, a preset count of 4000 was used.

The tube was operated at the mid-point of its voltage plateau to insure maximum stability. In addition a set of five standardized \$ emitters of known energy was periodically counted thus enabling the correction of observed counting rates for any changes in instrument sensitivity.

C. Corrections of Observed Data

V = a(1 + ab)

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Other than correcting for counter sensitivity
fluctuations mentioned above, the only correction
required was for resolving time losses. These corrections
were made by adding to the observed counting rates the
number of lost counts per minute (Fig. 2).

Applications (2) would not not not need only the skins of the skins profit that

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Counting procedure varied depending upon the titlekness of absorbers to high southing rates, the number of counts per t minute interval was recorded for at least them there in the counting rates, the process count feature at the ocaler was utilized and the time required for 10,000 counts was recorded. At very low nounting rates, a procest count of 4000 vars used.

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D. Resolving Time Losses

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It is generally assumed that the resolving time of an instrument is constant for all counting rates and corrections are usually made for resolving time losses by means of equations derived on the basis of two general counter types; the paralyzable and the non-paralyzable. A detailed treatment of these two cases* results in the following equations:

$$n = N(1 - n\rho)$$
 (non-paralyzable type) (2)

At low counting rates both equation (1) and equation (2) reduce to

$$N = n(1 + n\rho) \tag{3}$$

where F and n are respectively the true and observed counting rates and p is the resolving time.

In this experiment it was considered necessary at times to count at very high rates (~50,000 cpm) because of the possible presence of short-lived isotopes and the desire to obtain complete sets of absorption data as quickly as possible. It was obvious that the approximate equation (3) could not be used and it was also found that *Evans, R. D.: Class Notes for Course 8.512, Chapter 30.

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neither equations (1) nor (E) properly corrected the observed counting rates if a constant resolving time was assumed.

and resolving time loss, the restonse of the instrument to a series of standard sources of known activity was measured and a plot made of observed vs expected counting rate (fig. 1).* Two response curves are shown, one for a discriminator setting of 4, the other for a setting of 6.** From the curve for a discriminator setting of 4, the setting used throughout the experiment, a plot of lost counts per minute vs observed counting rate (Fig. ?) was prepared to facilitate correction of the observed data.

To verify the accuracy of this procedure, several sources were counted with discriminator settings of 4 and 6. The following tabulation of the counting rates observed and the true counting rates computed from the applicable curve of Fig. 1, shows that the computed values agree within experimental error thus indicating that consistent corrections may be made by this method.

^{*} Evans, R. D.: Class Notes for Course 8.512, Chapter 30, page 15.

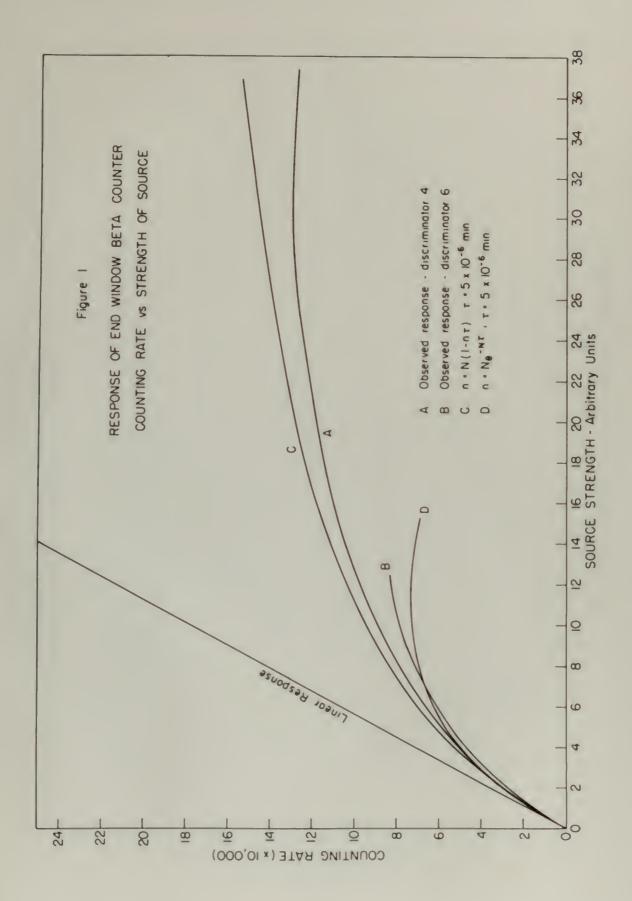
^{**} Data of E. Samuels, Physics Research Laboratory, Massachusetts General Mospital, Boston, Mass.

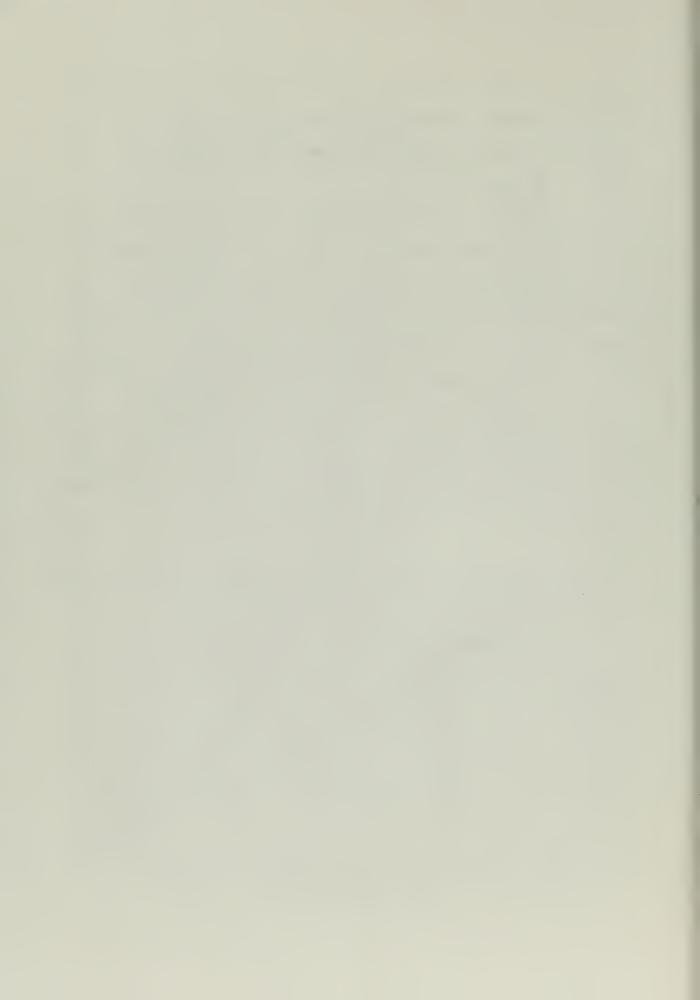
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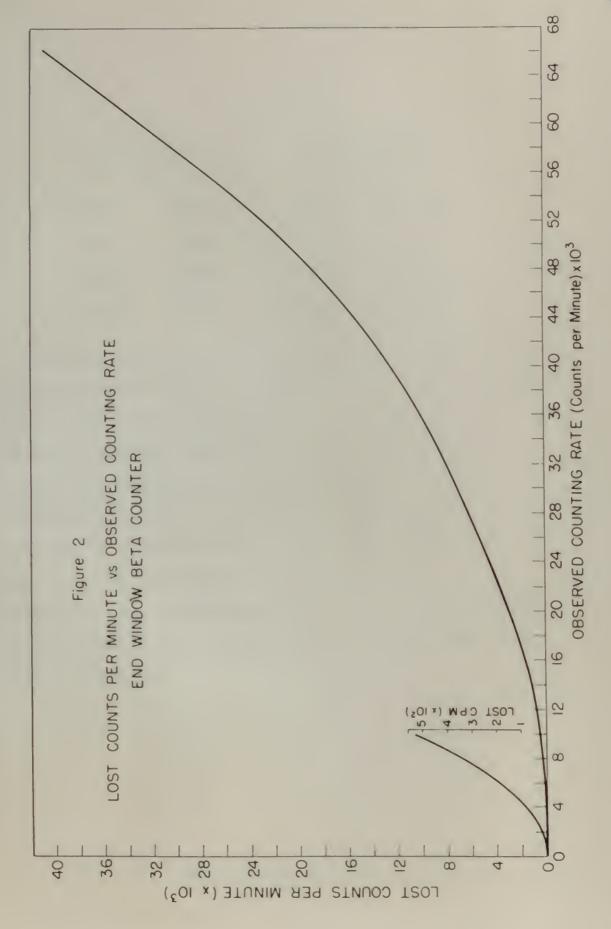
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Observed counting rate		Computed true counting rate	
Disc. 4	Disc. 6	Disc. 4	Disc. 6
10580	9850	10990	10700
41350	38910	54350	53900
67600	61100	110,000	109,000

Referring to Fig. 1, it is seen that neither response curve coincides with the theoretical curves of equations (1) and (2). It is apparent that the number of lest counts is strongly dependent upon the discrimination level. The results obtained may be explained by a consideration of the pulse height distribution as a function of counting rate.* This shows that as the counting rate is increased, many small pulses are formed end some fraction of these pulses is lost because of the discrimination level and not because of the dead time of the tube.

^{*} McCall, R. C.: "Geiger-Muller Counters", M.I.T.
Progress Report, 1953.

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^{*} McCall, F. C.: "Galgor-Muller Counters", ".1.1.

APPENDIX IV

THE COINCIDENCE COUNTER

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APPRIDIX IV

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APPENDIX IV THE COINCIDE CE COUNTER

A. Description

This equipment consists of two thellium activated sodium iodide scintillation counters connected in coincidence with single channel and coincidence scaling circuits driving mechanical registers. The crystals are 1.5 inches in diameter, 1 inch deep, and are mounted on RCA type 5-19 photosultiplier tubes.

The counters are contained in lead shielded heads along with their cathode follower type preamplifiers shown schematically in Fig. 1. The two heads are mounted on a mechanical scanning device such that the two opposing crystals are coaxial and are separated by approximately P7 cm. A mounting bracket permits positioning of a source equidistant from the crystal faces and colinear with their common exis.

The coincidence circuit is of conventional design*

providing both single channel and coincidence outputs which

* Dwg. No. B-1547-A, file 6-25, Laboratory for Nuclear

Science, M.I.T., 28 April 1950.

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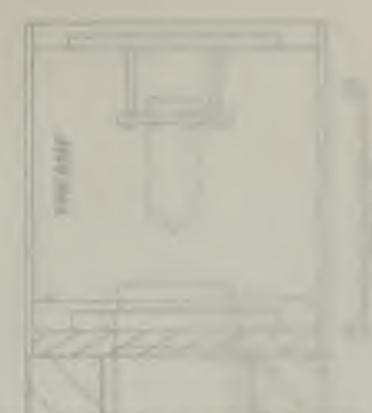


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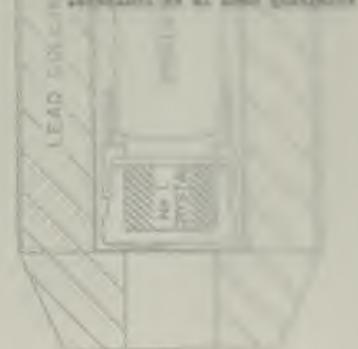
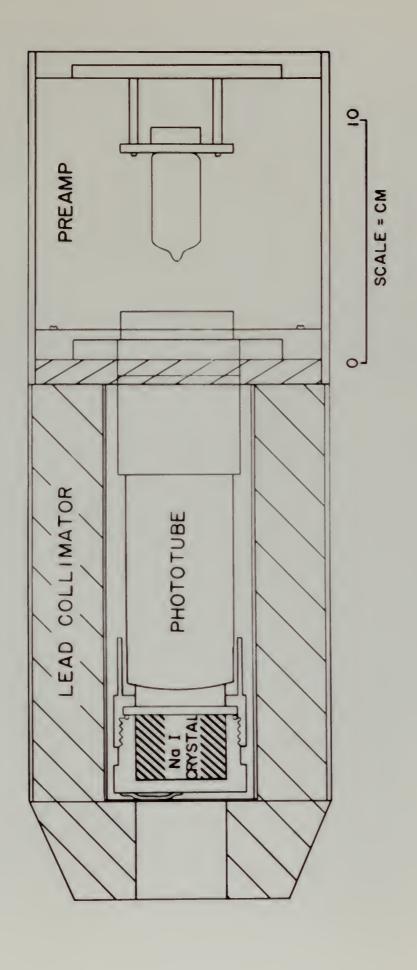
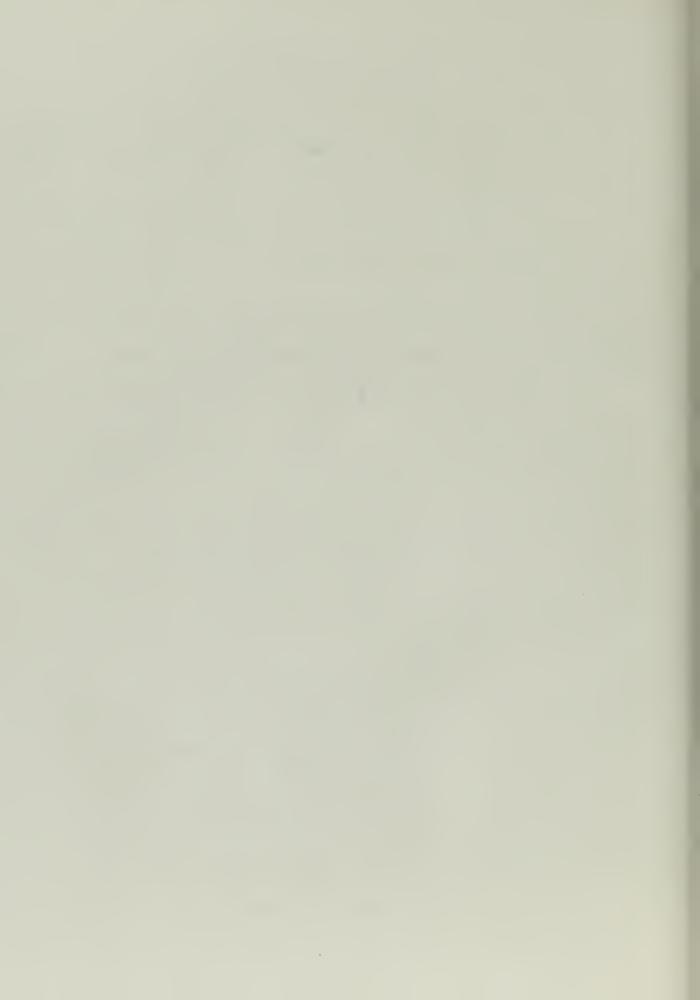


Fig. 1. Schematic diagram of scintillation counter.

The location of components within the lead shielding head is as indicate.





are fed through linear amplifiers* to separate scaling circuits**. The equipment assumbled for normal use is illustrated in Fig. 2.

B. Experimental Technique

The equipment is operated so that the individual channels register approximately equal counting rates when a source is at the mid-point on the axis between the counter heads.

Figure 3 illustrates that counting rates are only slightly affected by small displacements of the source from its central position. To minimize errors caused by variation in counter sensitivity due to other causes, a standard Na²² source was counted prior to each measurement and the correction thus determined was applied to the observed counting rate.

In all measurements the number of counts per 1 minute interval was recorded, each observation including at least three intervals for single channel counts and six intervals for coincidence counts. At least 10,000 events were included in each observation to insure a maximum fractional standard deviation of \(\le \) 1 percent.

^{*} Atomic Instrument Co. Model 204B Linear Amplifier.

^{**} Atomic Instrument Co. Hodel 1030 "Scale of 1000" Scaler.

are fed through linner amplifiers to separate conting sirediase, the explaners ausimbled for amount one in illustrated in Fig. 2.

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Figure 3 illustrates that counting patter are suity slightly affected by small displanments of the nonzeo from its central qualtion. To minimize across occase by warfables in counter semilibring for to other canesa, a standard is nourse was counted prior to make measure—near and the correction than determined was applied to the country and the correction than determined was applied to

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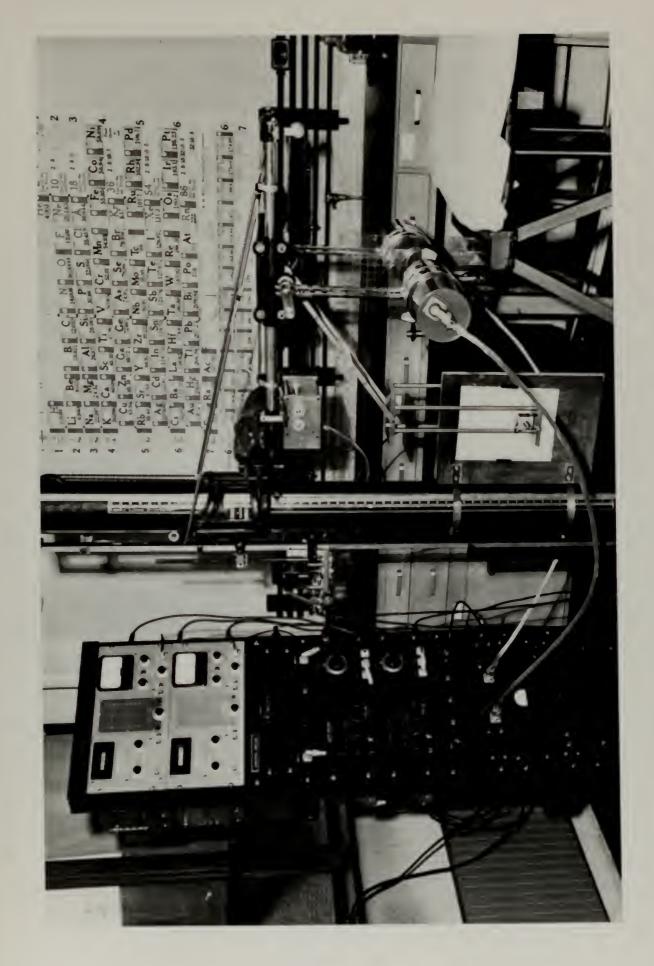
^{*} Atomic Instrument On, Hedel 2043 Linear Replifter.

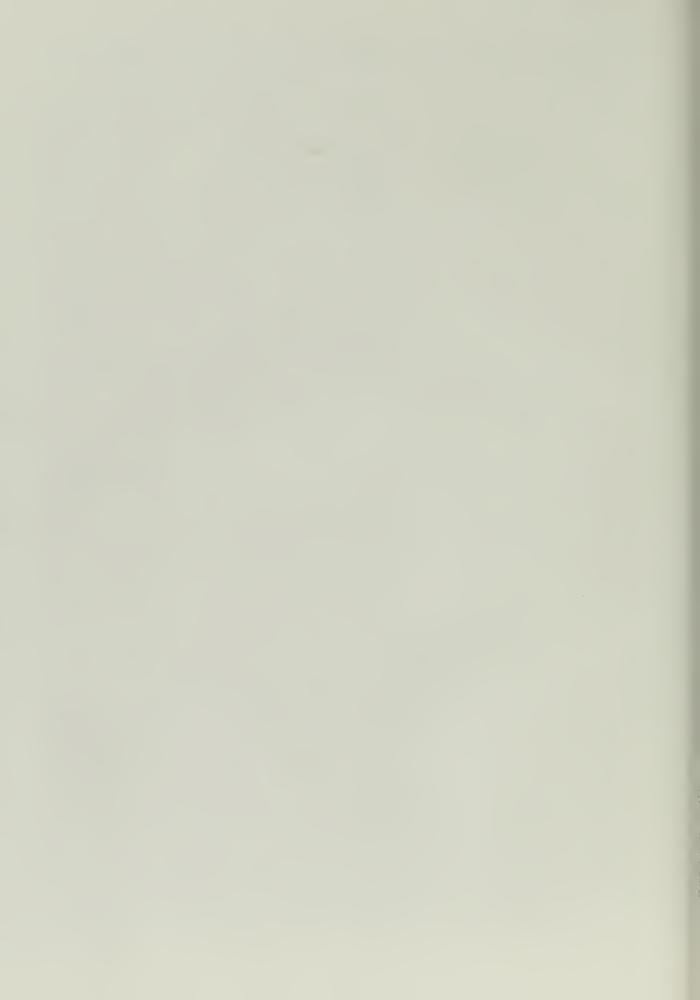
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NAME AND ADDRESS OF TAXABLE PARTY OF TAXABLE PARTY. and provided the first terminal for the Level and he benefits to revenue entition at the substance. The opposing last our of military was bright ourself building AND DE UN PRANTING THE Fig. 2. Coincidence counter assembly.

The equipment is shown as assembled for use in scanning measurements at Massachusetts General Hospital. The scanning and plotting mechanisms are contained in the central section of the photograph. The opposing lead shielded counter heads are visible to the right of the plotting board.

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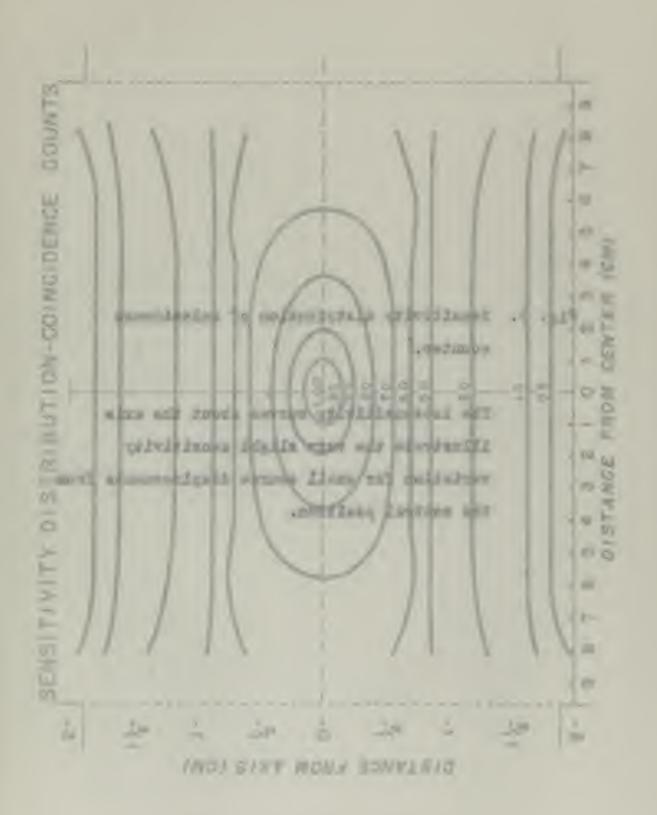
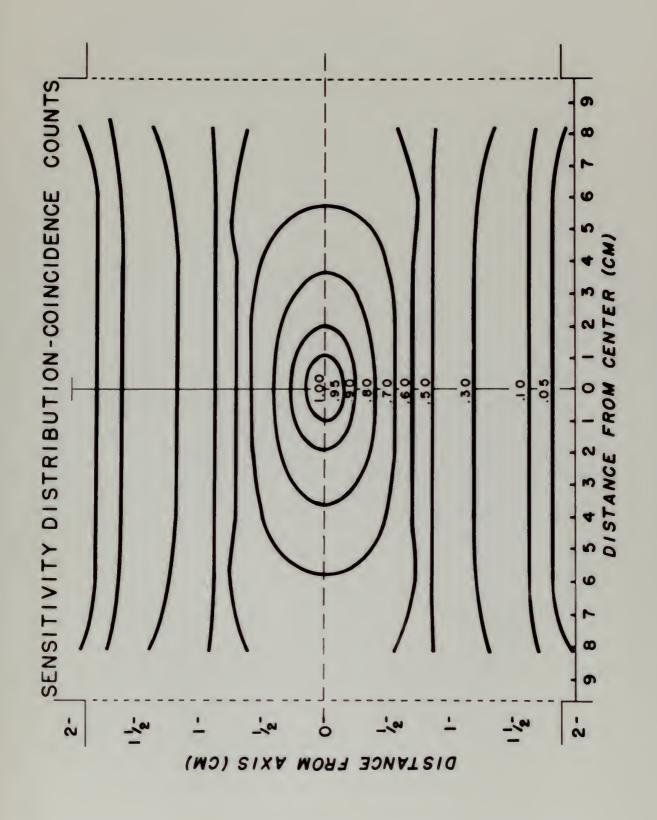
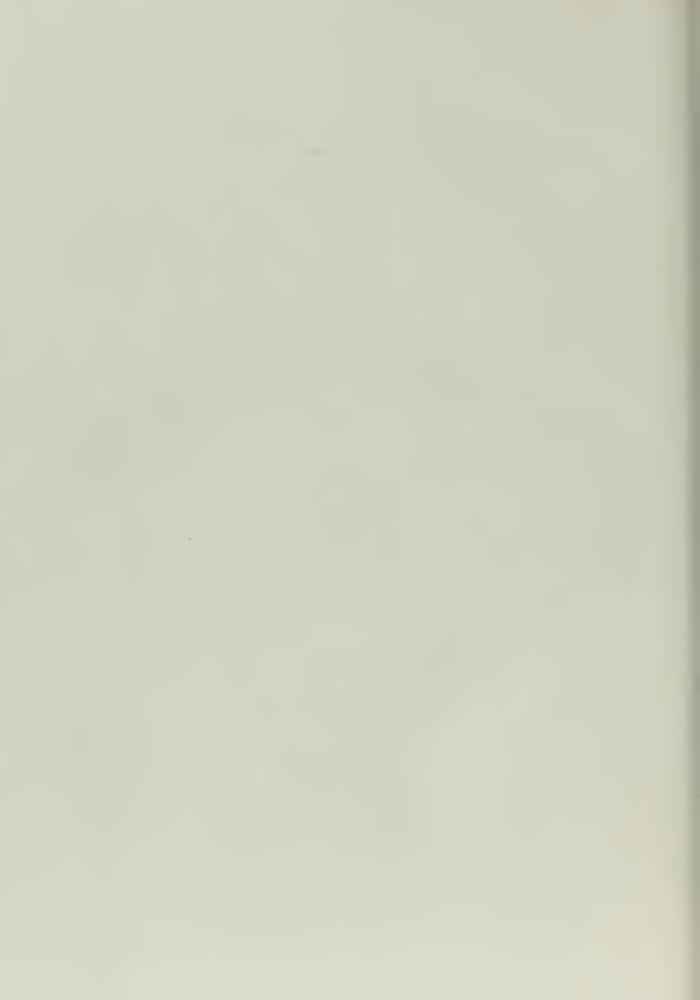


Fig. 3. Sensitivity distribution of coincidence counter.

The isosensitivity curves about the axis illustrate the very slight sensitivity variation for small source displacements from the central position.





C. Correction of Observed Counting Rates

Coincidence counting rates were corrected by subtracting from the observed values the chance coincidence rate. Chance rate was computed by means of the equation

where I_a, i_b are the individual channel rates and τ is the resolving time of the coincidence circuit. By counting an essentially consenergetic γ-ray emitter positioned off the axis of the crystals, τ was computed to be approximately 0.36 µsec by use of the above equation.

Counter response appears to be linear for counting rates up to 140,000 cpm on single channels and 14,000 cpm for coincidences (Fig. 4). Consequently no corrections were applied to the data for resolving time losses.

C. Correction of Observed Counting Pales

Coincidence constint rates were corrected by subtracting from the observed values the charge coincidence rate. Thence rate was computed by means of the equation $C_{\rm ob} = E \, T S_{\rm obs}$

where Y_a, Y_b are the individual channel same and T is the reserving time of the coincidence atreuts. By coincide an essentially amountagests year author postilosed off the axis of the arretain, T was computed to be approximately 0.34 page by one of the above equation.

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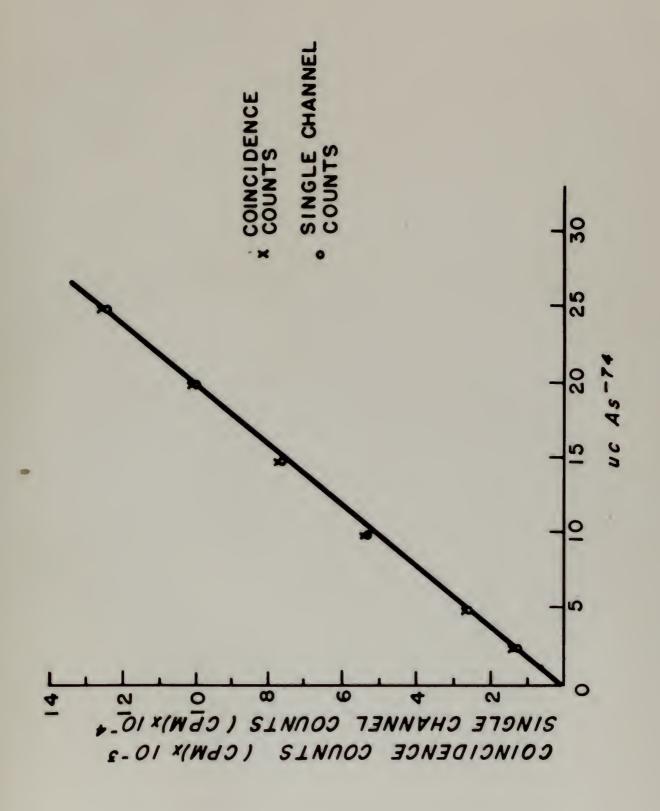
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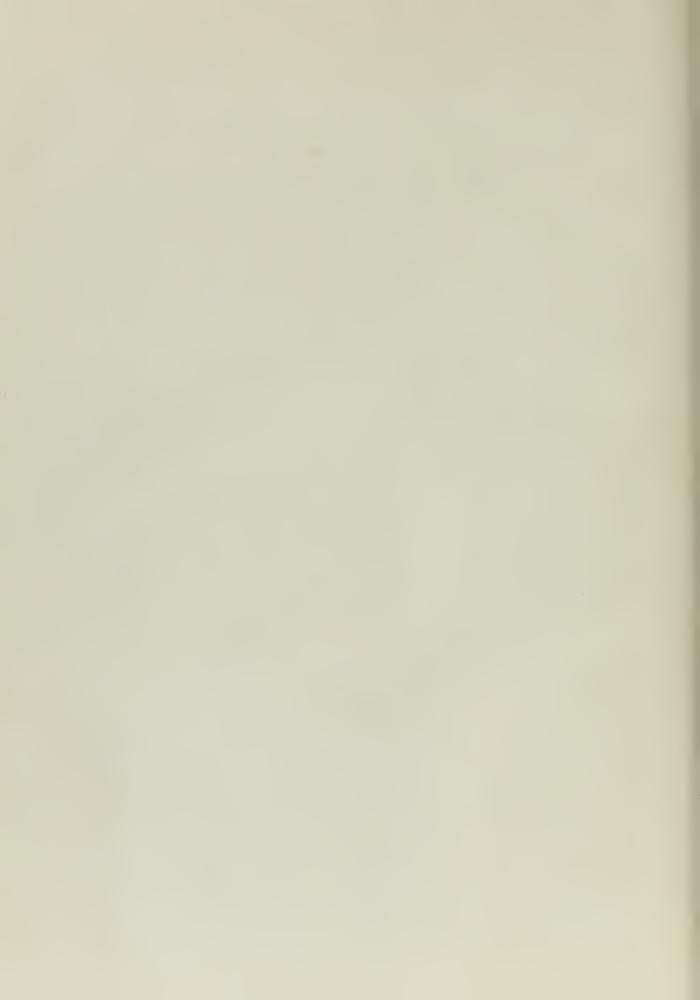
Fig. 4. Coincidence counter response curve.

The linearity of counting rate vs source
strength is evident for both single channel
and coincidence counts.

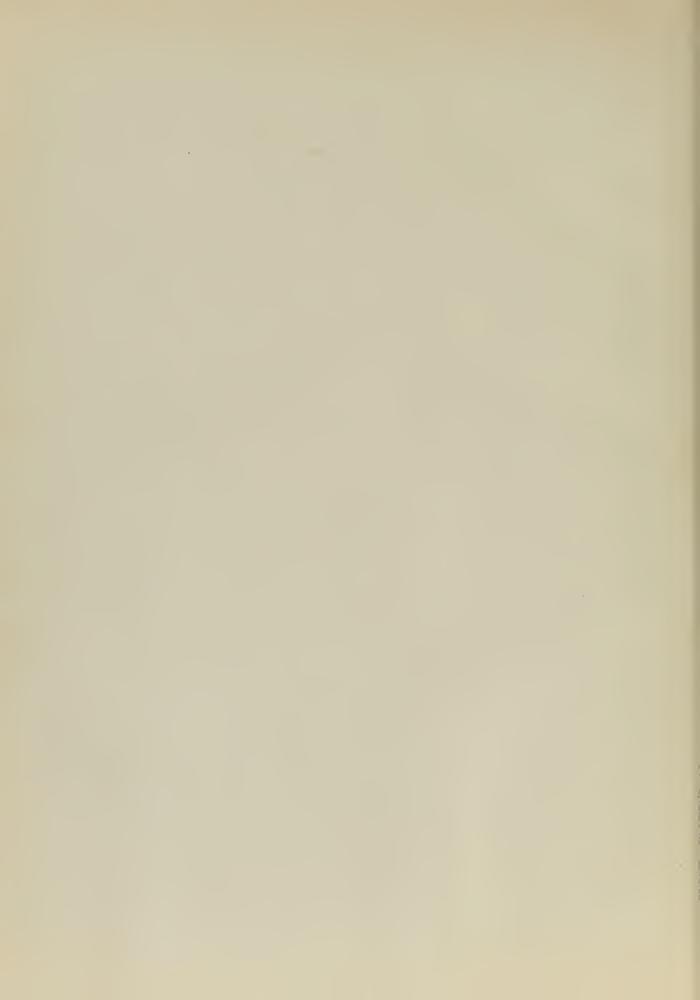
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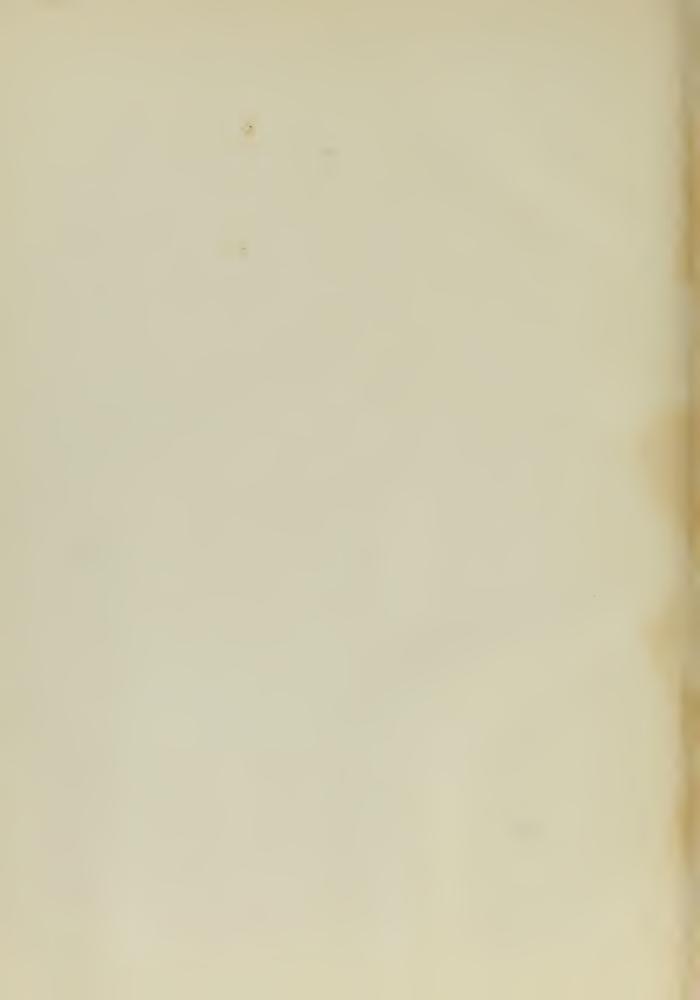












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